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Understanding kiwifruit management using causal mapping

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Summary

The Agriculture Research Group On Sustainability (ARGOS) is investigating the social, environmental and economic consequences of different management systems in different farming sectors in New Zealand (for more information visit www.argos.org.nz). Kiwifruit is one of these, and the systems being studied are KiwiGreen Hayward ('Green'), Organic Hayward ('Organic') and KiwiGreen Hort16A ('Gold'). 12 orchards under each system are being studied.

As part of the ARGOS social objective, causal mapping was used to document how the 36 participating kiwifruit orchardists described and explained the management of their orchards. This approach asks the participants to identify the factors which are important to the management and performance of their orchards and to link these on a map. The strength of these linkages was also recorded on a scale of 1 – 10 with 1 being weak and 10 strong.

The factors identified by the orchardists could be clustered into the following types:

- Production (e.g., weed and pest management).
- Social (e.g., family needs, neighbours).
- External (e.g., ZESPRI, Government policies).
- Financial (e.g., orchard gate returns, cash orchard surplus).
- Goals (e.g., satisfaction, retirement).
- Environmental (e.g., orchard environment health).

An aggregated or group map was produced from each of the individual orchardist maps. Data from the group map were used to characterise the overall orchard system as well as each of the three management systems being studied.

A predominant finding is the degree of similarity in the maps of growers from across all three panels. The overall group map which encompasses the three management systems had the following shared attributes:

- The most important factors were decision maker (i.e., the orchardist), quality and quantity of production, financial aspects (represented by returns, expenditure and orchard surplus), Marketing Organisation (i.e., ZESPRI), contractors/packhouse, and satisfaction.
- There were four main circuits: a production circuit, a production-related circuit (including post harvest quality), an expenditure circuit, and a fruit sales circuit.
- Fertiliser and soil fertility, and weed and pest management were the only factors of production with a strong link to quality and quantity of production, not labour or machinery.
- Fertiliser and soil fertility, weed and pest management, quality and quantity of production and contractors/packhouse were the only factors of production with feedbacks to decision maker.
- Satisfaction was derived from cash orchard surplus and quality and quantity of production.
- Orchard environment health was mainly influenced by the decision maker.

Causal map inferences show:

- In its final equilibrium state, satisfaction has a high level while marketing organisation and contractors and packhouse have a lower level.
- Results from maximising outgoing weights showed that removing satisfaction created the most change.
- Overall, the causal map is stable and significant change would only occur if many factors were changed, including the decision maker.

Despite these overall findings, there were still differences operating between the three panels of growers.

For Organic orchards, the key distinctive features compared to the overall group map were:

- The decision maker was linked slightly more strongly to orchard environmental health (6 compared to 5).
- Orchard environment health was linked more strongly to satisfaction (5 compared to 3).
- Orchard environment as place to live was linked more strongly to satisfaction (5 compared to 3).
- Fertiliser and soil fertility was linked slightly more strongly to production expenditure (6 compared to 5)
- Regulations was linked to the decision maker slightly more strongly (7 compared to 6).
- Orchard gate returns was linked slightly more strongly to decision maker (5 compared to 4).
- The decision maker was linked to fertiliser and soil fertility at a higher level (8 compared to 6)
- The decision maker was linked to plant and machinery at a slightly higher level (6 compared to 5)
- The decision maker was linked to time in farm work at a higher level (8 compared to 6).

For Green orchards the key distinctive features compared to the overall group map were:

- Contractors/packhouse was linked much more strongly to quality and quantity of production (5 compared to 2).
- Labour was linked to quality and quantity of production much more strongly (6 compared to 3).
- Contractors/packhouse was linked slightly more strongly to production expenditure (8 compared to 7).
- Weather/climate was linked slightly more strongly to quality and quantity of production (7 compared to 6).

For Gold orchards the key distinctive features compared to the overall group map were:

- Labour was linked slightly more strongly to production expenditure (7 compared to 6).
- Information was slightly more strongly linked to decision maker (7.5 compared to 7).
- This location was linked to the decision maker at a higher level (4.4 compared to 2.6).

The overall group map reflects a production orientation and that the kiwifruit system is perceived as more of a management system rather than an environmental one. Organic orchardists produced a group map having the most distinctive qualities but they also shared a small number of distinctive characteristics with Gold orchardists. Both used more connections and more double arrows compared to Green.

We conclude that the evidence supports the claim that at the aggregate level of the 36 kiwifruit orchardists the orchard system is not overly complex but at the level of each individual orchardist it is complex. Further, orchardists do not show a high level of holistic thinking about their orchard.

Regarding the role of ZESPRI in the system results show:

- ZESPRI was identified as one of the most influential factors in the orchard system.

- The factors perceived to influence ZESPRI in order of strength were customer requirements and exchange rate/macro economy.
- The factors found to be influenced by ZESPRI in order of strength were decision making of the orchardists and orchard gate return.
- There was no difference in the ranking of ZESPRI's influence between Gold, Green or Organic panels.

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Chapter 1

Introduction: Background, Research Objectives and Literature Review

1.1 Background

The social research objective of the Agriculture Research Group on Sustainability (ARGOS) research programme has already documented important information about farmers and orchardists. For kiwifruit and sheep/beef respectively, Hunt et al. (2005) and Hunt et al. (2006) have summarised the discussion of several topics from interviews with ARGOS participants, including: participants' visions for themselves and their farm or orchard and the constraints to those visions; indicators (as identified by participants) of productivity as well as the financial and environmental wellbeing of farms or orchards; the farm' or orchards' affect on individual, family and community wellbeing; and the factors that ARGOS participants felt they were managing well and those that were difficult. Finally, the reports examine the expectations of farmers and orchardists as a result of their participation in the ARGOS programme. In addition, Read et al. (2005) reported on the analysis of farm sketch maps participants drew in the first interview in order to illustrate the important factors in the management of their farms or orchards. This analysis showed that the design and content of the maps were influenced by the region and landscape in which the farms and orchards are located as well as the importance of boundaries, neighbours, organisation of the farm and the orchard, and the mitigation of risk.

These reports from the first interview give a detailed account of many aspects of ARGOS participants' situation, including how they managed their farm or orchard. However, management was one topic among many and the understanding developed, while detailed, was not systematic. The following analysis provides an important step toward developing a better understanding of how participants think about and manage their specific farm or orchard system. Such a grounded study of farm and orchard management is essential to the ARGOS research programme.

ARGOS has an explicit transdisciplinary approach to the design and conduct of its research. This approach facilitates analysis of the farm or orchard as a complex system, taking into account all the relevant components or factors involved in its overall management and direction. This founding principle is reflected in the methods we use to understand how farmers operate or make sense of their world. In order to understand farmers, we need to use an approach which recognises the nature of the reality in which farmers live and interact. As Galmiche-Tejeda (2004) argued, farmers think and address problems holistically, not by analysing them into parts such as physical, social or economic. They argue that farmers look for the links between the parts, conceiving of problems as a whole, seeking solutions which can be found by an integrated analysis of all the parts of their system. This is an important assumption about farmer practice that will be critically tested in this report. Accordingly, research methods need to have the capacity to engage with these multiply integrated dimensions of farmer activity. An ideal method should allow farmers to tell the researchers what the key elements or factors are in their system, and how they understand these factors to be related. We argue that one such approach is cognitive mapping whereby the factors in a system are drawn in two dimensions with arrows connecting the factors to show causal influences. The literature review below shows that cognitive mapping is a relatively new research method and that it has seldom been used to study farming systems. However, there is one exemplar in the literature which, in our opinion, has promise in meeting our wish to

understand management and to develop this understanding in ways that are compatible with how farmers approach management.

1.2 Research Objectives

The primary research objective is to document how orchardists participating in our ARGOS research describe and explain the management of their orchard system. The research aims to develop a full account of such perceptions by identifying the factors that comprise their orchard system and by showing how the factors are linked. Accordingly, it allows us to engage with the degree and depth of 'systems thinking' by growers when managing their orchards. It does this by employing a cognitive mapping method in which orchardists portrayed their view of their orchard system in the form of a map. A second research objective is to assess the results for any patterns in the way farm systems are seen and understood. Specifically, we shall test the ARGOS null hypotheses that there is no difference in the perceptions of management across the three different management systems under study (KiwiGreen Hort16A, KiwiGreen Hayward, and Organic Hayward). Meeting this objective also entails consideration of the ways that the panels may be similar. A third objective is to contribute towards some specific social objective aims, namely to identify sites of action for farmers, that is, places where action to achieve sustainability may occur, and perceived constraints on that action. We expect that the different factors involved in management and the linkages between them can contribute to these latter two goals. A final objective is to contribute to modelling the environmental systems in which farmers operate. By developing farmer-based models this component of the social research can make an important contribution to modelling initiated by ARGOS ecologists and informed by economic considerations, thereby contributing to our transdisciplinary aims.

1.3 Literature on cognitive mapping relevant to farming

Early on in our research we found Ozesmi and Ozesmi (2004) fuzzy cognitive mapping to be relevant and to show great promise. Our subsequent literature review showed that cognitive mapping has been used in a variety of ways but is still relatively new and variably used, and few researchers have developed and applied it so well as Ozesmi and Ozesmi (2004). There is a body of related literature which uses mapping to solve problems, typically those associated with business and management (e.g., Bryson et al., (2004), Eden and Ackermann (2004)), but this approach does not involve weighting causal connections between factors and does not allow the kind of quantitative developments led by Ozesmi and Ozesmi (2004). Consequently, we give a cursory review of how cognitive mapping has been used to illustrate its applications and then later provide details of fuzzy cognitive mapping.

In the literature we have identified, cognitive mapping has been used mainly in the resource management area, and occasionally in some other fields such as marketing and tourism. Seldom has it been applied to farmers. The main application of cognitive mapping in the resource use area has been in forestry where it has been used in a variety of ways. Some researchers have included it in reviews of methods, in trying to achieve adaptive management, and in perception studies. For example, Mendoza and Prabhu (2002) set out various ways of making forest sustainability assessments and included cognitive mapping as one method of showing interactions between and among a number of indicators. They argued that by looking at the strength of the connection between the indicators, it would be possible to identify the strategically important ones so that managers can identify indicators that need attention, monitoring or mitigation. In effect, Mendoza and Prabhu (2002) set out how cognitive mapping can, in principle, be used to improve forest management. In contrast, Graham and Kruger (2002) used cognitive mapping in a study of how nine scientists in the US Forest Service understood and applied the research process. A variety of methods were used, including a questionnaire on preferred mode of thinking (Hermann Brain Dominance

Instrument), cognitive mapping and interviews. The results, without featuring the cognitive maps, were used to make recommendations for adaptive management efforts.

A number of forestry perception studies have used cognitive mapping. For example, Colfer et al. (2001) assessed peoples' perceptions of forests in West Kalimantan, Indonesia, to determine if the people there had a conservation ethic. Using a variety of local objects such as fish, wood, rattan, honey, garden, animal, food, soil etc, they developed a cognitive map from a plot of the results of averaging the cognitive measurements made by the local people. As such, this study did not rely on participants creating the cognitive map. In contrast, Kearney et al. (1999) studied stakeholders' perspectives on appropriate forest management in the Pacific North West. The 23 participants from three stakeholder groups completed a cognitive mapping task and the results showed that the patterns of similarity and differences among stakeholders groups were complex and deviated substantially from common stereotypes. Participants' perceptions of other stakeholders were highly stereotypical and not supported by the data. The method used is known as the 'conceptual content cognitive map' (3CM) task and is based on the work of Kearney and Kaplan (1997). With this approach subjects first identify relevant factors, then organise the factors into groupings, and then explain the groupings. These latter studies appear to be genuine cognitive mapping research in that participants made cognitive maps that the researchers then used.

In related forestry work, Skov and Svenning (2003) made GIS-based predictions of plant distribution linked to environmental factors which were adequate only at the broad scale of the overall forest. More detailed predictions at the site level required the use of expert knowledge obtained by cognitive mapping. In another study, Altıncelik and Erdonmez (2001) documented park users' points of view on landscape in Istanbul, Turkey, using a variety of methods including cognitive mapping. Beyond forestry, Popper et al. (1996) examined agricultural pesticide use in rural Guatemala and interviewed farmers and housewives using a variety of instruments, including cognitive mapping, to build a map of knowledge and beliefs regarding pesticides. Hjortso et al., (2005) developed an understanding of stakeholder views relating to buffer zone management in the coastal wetlands of southern Vietnam using Rapid Stakeholder and Conflict Assessment (RSCA) methodology which included qualitative interviews and cognitive mapping. Their mapping was based on Eden's approach (e.g., Eden and Ackermann (2004) which draws on Kelly's (1955) personal construct theory and has the researchers facilitating the development of the map or construct system. Individual maps are merged by the facilitator into a comprehensive map which then allows the group to plan actions for the future. In this application of the method, interviews can be done with individuals or groups. Giordano et al. (ND) used cognitive maps to contribute to community decision support systems for water resource management. Again, there was a focus on the cognitive maps of different stakeholders but then these were used to encourage negotiation among stakeholders. They drew on the work of Eden (who has played a prominent part in UK research on cognitive mapping) and Ackermann (2004) to apply their approach. In other applications, Krystallis and Ness (2003) developed an understanding of Greek food consumers' motives for purchasing high quality food (represented by olive oil) by interviewing 40 people and developing a cognitive map which linked olive oil quality, use benefits and consumer values.

These applications of cognitive mapping generally had an applied orientation and shared a similar approach of using mapping to understand the positions of different stakeholders. Since many of the settings for these studies were rural, the stakeholders included farmers. In some cases the researchers used cognitive mapping among a suite of methods and given the amount of time usually involved in cognitive mapping it is unlikely that they were dedicated or thorough cognitive mapping studies.

One conclusion to be drawn from the literature is that cognitive mapping has not often been used in any definitive way for research on farmers. Only two studies were found that did

include farmers. Botha and Verkerk (2002) used cognitive mapping to examine decision making of dairy farmers in New Zealand, focusing on how they decided to induce calving. Three groups (a dairy farming couple, three dairy scientists and a group of nine dairy farmers) were interviewed to generate cognitive maps using post-it notes and allowing participants every opportunity to make changes. Three maps, one for each group, were developed and compared, the maps having 16, 25 and 40 factors respectively. These maps were used to show the considerations and rationale for using induced parturition. The authors concluded that interactions between the different factors that influence induction become more apparent and more obvious to participants when these factors were made visual through the cognitive mapping process. The authors also commented that cognitive mapping needs to be applied over time rather than at critical decision making points. This study is innovative in its application of cognitive mapping to farmers but was limited to two groups - one comprising two dairy farmers and one comprising nine dairy farmers.

In the other study, Naidoo (2002) used cognitive mapping to understand the structure of thinking about information sources among small-scale cattle farmers in a village in Mauritius. The researcher developed cognitive maps from interviews and observations, and then presented these to the farmers for checking. Nine information structures developed. They were relatively simple flow diagrams which showed how farmers proceed in an organised and hierarchical way of thinking about looking for, using, storing and communicating information relevant to their needs.

In a study related to cognitive mapping which used both survey and interview results, Corselius et al. (2003) studied the decision making of cropping farmers in north western Minnesota. They found three dominant conceptual frameworks, or 'mental causal models', which explained decision making. These models entailed differing views of causality when addressing a complex and 'uncontrollable' situation such as scab disease. Despite similarities in their understanding of the biological and climatic basis of the disease, the farmers drew quite different conclusions about the source and implications of the problem. This study approached farmers' understanding of important aspects of farming in a different way to the cognitive mapping approach but produced similar findings in terms of the general pattern of results. Interestingly, they referred to their models as 'causal' models. In broadly similar work, Peverelli (2004) used 'cause maps' drawn from secondary data to elucidate how a prominent incident in China, milk dumping, was understood by a variety of stakeholders. He drew from published accounts of the incident to develop a map for each stakeholder group and compared the different maps in terms of common factors. In his conclusion he considered how interactions between different stakeholders could be developed to lead to temporary coalitions and the development of a Dairy Board. These two studies introduce the idea of cause to mapping.

The most explicit and detailed example of cognitive mapping is Ozesmi and Ozesmi (2004) who have done considerable research in the resource management and conservation area studying, for example, a national park proposal for a wetland area in Turkey and hydro-electric developments and resettlement. Their studies included farmers and other stakeholders with a focus on ecosystem management rather than farm management per se, but this focus clearly overlaps with farm management. We need to examine their approach in more depth, as it raises important issues about appropriate methods and claims to have potential for understanding how farmers think about the management of all the factors involved in their ecosystem. Accordingly, the Ozesmi and Ozesmi (2004) approach provides the most ambitious scale and scope of mapping – taking the analysis well beyond the specific farm-related issues demonstrated by some of the research reviewed in this chapter. The Ozesmi and Ozesmi (2004) work not only includes whole farm systems, but also a broad sweep of wider ecosystem processes in which farming activities take place. The next chapter explains and evaluates Ozesmi and Ozesmi (2004) in more detail.

While the literature consistently uses the term 'cognitive mapping' we take a different tack and use the term 'causal mapping'. We do this because the term 'cognitive mapping' suggests that the map is purely a product of cognition. In this view, reasoning and intuitive processes lead to the map which in some way represents the thoughts of the participants. For the authors of this report, who are all social scientists, the term 'cognitive mapping' overemphasises cognition and underemphasises social factors beyond the subjects' thinking that play an important part in influencing the subjects and their cognition processes. As a means of addressing the need to recognise these social factors, we see the mapping process as showing causation between factors, including significant social factors. Hence we employ the term 'causal mapping'. We note that Bryson et al., (2004) also use this term in their book on visible thinking.

1.4 Outline of report

In Chapter 2, Ozesmi and Ozesmi's cognitive mapping approach is introduced, critically reviewed and an explanation is given on how it was adapted for use in this study. In Chapter 3, the results of the ARGOS study are presented followed by Chapter 4 which includes a summary of the results and provides discussion and interpretation.

Chapter 2

Method: Causal Mapping as a Type of Cognitive Mapping

2.1 Introduction

This chapter describes Ozesmi and Ozesmi's (2003) approach to fuzzy cognitive mapping, critically evaluates it and then explains how their approach was modified in its application to the study of 36 orchardists in New Zealand. The chapter concludes with an overall assessment of causal mapping noting its strengths and limitations.

2.2 Fuzzy cognitive mapping (FCM) outlined

Ozesmi and Ozesmi (2004) build on earlier research (Ozesmi, 1999) to show how to build ecological models based on people's knowledge using multi-step, fuzzy cognitive mapping (FCM). A cognitive map is a qualitative model of how a given system works. It comprises factors, and causal relationships between these factors. Maps are constructed by asking respondents to identify the components or factors in their ecosystem, then asking them to link the factors with arrows and assign numbers to the arrows to show the strength of the connections. Individual maps can be examined, compared, added together and the effects of different policy options can be considered.

Ozesmi and Ozesmi (2004) outline a number of steps in FCM. In the first step, maps can be obtained from written texts, questionnaires, data that show causal relationships or interviews. They emphasise interviewing as the appropriate way to develop maps. Interviewing starts with the participant listing all the factors that come to mind when they consider the ecosystem and its surroundings and inhabitants. Participants then take the factors one by one and draw them on a large piece of paper showing how they are linked by using arrows. The arrows show both the direction and strength of the relationship. Mapping finishes when as many factors are drawn and connected as the participant chooses.

Once maps are obtained and consideration has been given to an appropriate sample size, they are coded into an 'adjacency matrix' which is merely the listing of all factors on a two dimensional chart so that the weightings of all arrows can be entered into the appropriate cells. By using both sides of the matrix it is possible to record the strength and direction of causality, including situations in which two factors are in a feedback loop or mutually influence each other (bi-directional arrows). Graph theory allows for the analysis of the FCM in terms of a number of attributes that characterise the structure of the maps. For example, one can assess the number of transmitter factors (factors which only have arrows leaving them) and the outdegree (the sum of the values of such arrows).

With these attributes measured one can examine individual maps in these terms and then compare cases or groups of cases (stakeholder groups). Further, one can combine maps to create a 'social cognitive map'. This then reflects the combined factors and weightings for the group and is an indication of how the system works. Note that these steps require identification of similar factors and the focus is on one ecosystem. In addition, for both individual and social maps, since they represent systems, it is possible to 'run' the system using neural network computations to see where it will go in order to achieve a steady state. Finally, the system can be run using various policy options to assess various scenarios.

While the scope and scale of mapping by Ozesmi and Ozesmi (2004) is ambitious, they do note a number of disadvantages of using cognitive mapping to attempt to understand whole ecosystems. As these issues relate to key debates in agricultural sustainability, they are worth more in-depth consideration. In particular, their mapping approach does not satisfactorily resolve the division between lay/expert knowledges. First, if the assumption is made that participants only have a partial or incomplete view of ecosystems, then the participants' knowledge, ignorance, misconceptions and biases are built into the maps. On the other hand, many sustainability experts argue that lay knowledges are important as a counterbalance to the abstract and uncontextual knowledge of 'experts' like scientists and government experts. Overcoming this divide is therefore seen as being critical to achieving sustainable development.

Ozesmi and Ozesmi (2004) take a rather pragmatic approach to this problem. They argue that this problem can be partially overcome by combining maps from both lay and expert sources. By including many experts and lay people the accuracy of the map can be improved. Ozesmi and Ozesmi (2004) explain that knowledge estimates improve with the number of experts or lay people, if they are viewed as independent or unique random knowledge sources with a finite variance and an identical distribution.

Other disadvantages include the fact that while scenarios can be considered, the maps do not explain why an outcome of a scenario is obtained, they do not provide real value estimates or inferential statistics, they cannot model changes in behaviour, and they do not handle 'and' or 'if then' conditions. Put simply, the scale of the problems being addressed are so great, that the maps perform a useful service just getting all the relevant causal factors into play, let alone modelling their change or wider causal influences.

Ozesmi and Ozesmi (2004) conclude that on balance, the advantages of FCM outweigh the disadvantages and FCM is useful in obtaining the perceptions of different stakeholders concerning ecosystems. Importantly for our study, they suggest that FCM can be used for meta-analysis where people's perceptions of ecological systems in different areas can be compared.

2.3 Evaluation of FCM

FCM is relatively unproblematic at the level of the individual maps. The method appears, in principal, to be a straightforward application of a qualitative technique even if, as our experience indicates, the actual process can sometimes be demanding for some farmers to do. In keeping with qualitative research, Ozesmi and Ozesmi (2004) emphasise that each map is a qualitative model of how a given system works and they claim that formal validation is not possible because the maps operate on different understandings of the system and do not yield outputs directly measurable in nature. They argue that assessing whether one map is better than another may not be possible because the reality with which the model is compared is in fact the manifestation of another understanding. This claim seems defensible but their subsequent discussion on this point is not convincing. They mention that in one study the villagers disputed the level of biodiversity assessed by experts but Ozesmi and Ozesmi (2004) did not explain how this should be resolved. It may be particularly interesting to have a map with factors or linkages that are contradicted by scientific findings. It is also problematic if the objective is to develop a robust model, and the emerging model has some factors and their associated relationships that are not supported by the balance of well-founded scientific opinion. Their discussion of this point merges into the issue of validation and complexity of maps. In our view there seems to be a role in validating maps with scientific evidence because it may be the case the local understanding and representation is seriously flawed. However, as we note below, such a map is valuable since it shows how participants see the situation. It is also possible that science may have overlooked some factors and relationships and the lay map is a better representation of an ecosystem. This

issue of map validity is a challenging one and we will return to it in the conclusion of this chapter.

A minor point relates to the use of the word 'social' map. We need to be clear that the word social in this case is not necessarily referring to a primary group of interacting individuals. This is still an acceptable use of the word since the individuals are behaving in ways that reflect the presence of others, and in this sense they are a secondary social group, and the map that is an aggregation of these individuals can be called a social map. However, in some applications of cognitive mapping the mapping process itself is performed by a group to produce a more genuine social map. In recognising this distinction and to avoid over-privileging the sense of social we adopt the term 'group' map for the aggregated maps.

FCM becomes more challenging with the claim that the group map represents an ecosystem. At the level of collective perception this claim is sound but some care is needed with how far one can go in this direction without entering difficult territory in terms of lay/expert knowledges. Ozesmi and Ozesmi (2004) acknowledge that there is an issue with map accuracy when only using the perceived relationships identified by lay people, and they suggest that accuracy can be improved by seeking input from many independent experts.

There are two related issues here: (1) the composition of the sample and (2) the accuracy and validity of the group map. Regarding the first issue, it seems axiomatic that the nature of the results depends on who goes into the sample. In a study of a lake ecosystem such as the one in Turkey that Ozesmi and Ozesmi (2004) report, the local people did the mapping and their maps contributed to the group map. It was not clear if ecologists contributed but, in principle, Ozesmi and Ozesmi (2004) say that diversity is good and experts should be included. In some qualitative methodologies, such as Q methodology (Fairweather and Swaffield, 2000), the guiding principle is to select a diverse, non-random sample in order to ensure that the results reflect these viewpoints. However, Q methodology allows for low frequency and unusual views to have an important influence on results whereas FCM, by simply adding together the individual map data, means that minority viewpoints may be averaged out and will not contribute significantly to the character of the overall results. The precept to ensure diversity in the sample may not work well with FCM.

Regarding the second issue, the accuracy and validity of the group map becomes irrelevant if researchers are exploring how a system is seen from the perspective of the participants irrespective of the accuracy of their description. While in many cases local farmers are experts, it is debatable if they always hold sufficient expertise to know their local ecosystem. What if there is actually a poor understanding of how the local ecosystem works? Putting it another way, we can be confident that the map represents what the stakeholders or participants think, but the structure of their thinking is not the same as the structure of the ecosystem. This problem can be illustrated with the following hypothetical finding. If one half of a group of local farmers see X causing Y and one half see Y causing X, with equal strength, then the additive process of the group map means that the result will show nil causation between X and Y. This is something of a unsolvable dilemma, and is a major reason why this report emphasises that the maps represent a 'perceived' as against a 'real' ecosystem.

Perhaps it is the case that many poor opinions do not good knowledge make. However, there is evidence that this concern may not be well founded. Surowiecki (2005) in *The Wisdom of Crowds* argues persuasively that under certain conditions of diversity, independence and disaggregation, collective decisions can be better than individual decisions because individual errors in assessment are cancelled out. His theory and its application to many examples show that collective decisions can lead to positive outcomes despite the individual limitations of each contributing decision maker. This view is also supported by those who work with the concept of distributed intelligence (e.g., Taylor, 2001).

Another concern is the application of set theory concepts to the actions of humans. Ozesmi and Ozesmi (2004) characterise individual maps as either hierarchical or democratic, the latter having a higher level of integration and dependence. They suggest that stakeholders who produce more democratic maps will exhibit a greater likelihood to adapt to local environment changes and to perceive that the system can change because they see more networks and possibilities for action. But this claim seems to ignore the role of power. In any ecosystem there will be structural constraints on action that would work against the intentions of even the most 'democratic' of people

Even if the maps lack comprehensive validity (or their validity can not be proven), their value for recording how farmers see their system can not be overstated. There are a number of considerations here.

What could be very important is the juxtaposition of farmers' maps and experts' maps. If there are differences in conceptions between farmers and experts then this is critically important in any movement towards improved sustainability. If no attention is given to this divide then policy derived from the expert side is highly likely to fail when it is oriented or applied to farmers who see the ecosystem in a different way. This is why much of the literature emphasises that the development of policy should respond to how farmers see their ecosystems. Similarly, policy derived from farmers' side may be flawed if the farmers' model is itself flawed in some way. Ideally, it would seem that some kind of balance between lay and expert models would be the best basis for policy. Behind these considerations is the point made above that we are dealing with models of ecosystems which approximate to some greater or lesser degree the reality which they represent. Neither the lay or expert model is necessarily best in this regard.

Beyond the validity of lay and expert maps is a more subtle issue of the character of the maps themselves. It may be that ecologists see an ecosystem in a qualitatively different way compared to farmers. For example they are likely to take a non-anthropocentric view, but still acknowledging that the farmer is an important part. Or perhaps farmers are thorough-going systems thinkers and have a good balance between themselves as an important factor and the other factors in their system. It seems likely that farmers with their often long experience of their land and an interest in aesthetic aspects of their farm would have a systems view. This view is often taken in the literature which emphasises a democratic ethos of aware farmers managing their land in the best possible way.

It may be that on some important aspects, both the farmers' map and the experts' maps are wrong. Improvement in each requires comparison and dialogue of some type in order to improve map validity. Given that scientific knowledge is incremental and never final, it may be possible that local expertise does exceed that of the scientists. This would be particularly relevant for situations where the scientists did not have a detailed body of data on which to make their claims

A final consideration is the application of FCM to ARGOS research where we have panels comprising 12 farms and a total of 36 separate farms for each sector. FCM in its purist application would seek input from many individuals for a single farm and its ecosystem. By having each farmer in the panel do a causal map we have one expert documenting one system. Therefore the question is: can the maps drawn by 12 farmers in one panel (or 36 farmers across all three panels) be used to form a group map for that kind of farming generally? For their part, Ozesmi and Ozesmi (2004) suggest that meta-analysis is possible. In the case of our ARGOS research, in as much as the farms are similar, it would be possible to form a group map of the sector; but, in reality, the farms are different since they are located across New Zealand. It is possible that farm differences mean that any aggregation may be problematic. However, we still need to consider aggregating the results as it may be that despite the farm differences there are still some commonalities or some basic structure

to the management of farming for that sector. In building a common map for each of the farming systems (conventional, integrated, organic) within a sector the locational effects would be averaged out. When each factor on the map is considered separately, comparative analysis across the farming systems using ANOVA can take account of location. Another consideration is that some of the factors are external to the farm and presumably the same for each farm, e.g., government policies, weather. This may mean that there is a basis to aggregating the individual maps.

2.4 Development of our causal mapping approach

Our application of causal mapping started with Ozesmi and Ozesmi's (2003) approach but was modified in the light of early results. The following sub sections show the initial starting point and how our application of the method changed. The first important modification was to focus in on farm management, and the actions of decision-makers on farms rather than attempt to get participants' views on whole ecosystems. Further, because farmers found mapping difficult to do, one technical modification was to present a generic map without arrows. Subsequent pre-testing involved modifying the generic map mainly by adding or renaming factors. We also developed a set of questions to ask about the completed map, the answers to which provided some further insight into the maps. Interviews with orchardists took place during March and September 2005.

Pre-testing of causal mapping

A pre-test sample of eight farmers and growers consisted of colleagues at Lincoln University who were also farmers or growers, and some nearby farmers and growers. Each was shown an example of a simple causal map taken from Ozesmi (1999) which showed a Turkish villager's map relating to the amount of fish in a lake. The research topic was introduced by asking:

When you think about your farm or orchard, including its surroundings and its inhabitants, what are all the factors/things that come to your mind? How do they affect each other? Please include yourself, and the social, economic and environmental factors.

Each subject listed the factors involved in their farming and then drew a causal map. Maps were quite varied in their lay out and coherence. Some farmers located the factors haphazardly on their map while others deliberately placed a factor near to others with which it was later connected.

Overall, the pre-testing showed a number of things. First, while the focus was intended to be on the ecosystem, farmers focused on production. For example, all subjects included soil as a factor. There was no reference to the health of the environment. Second, the process allowed quite diverse systems (cropping, dairy, glasshouse and smallholding) to be encapsulated in about 60 minutes. Third, the map was able to evolve through the interview. Adding weights required sharpening the labelling of factors and in some cases it led to initially 'forgotten' factors being included in the map. Finally, none acknowledged that any key factor of production causally influenced farmer decision making.

In order to test the causal mapping process with farmers less familiar with thinking about their farming in abstract terms, a further six interviews were arranged with sheep/beef farmers near Geraldine. These interviews were conducted in a similar way but the mapping

was followed by some questions that appeared to be important for developing a better understanding the maps¹. The questions were:

What are you trying to maximise or improve? Minimise or avoid? What is at the heart of your system?

To what degree can any of the elements of the system change? Can the system change? What causes these changes? Can you change them? Is the system likely to change? How resistant to change is it?

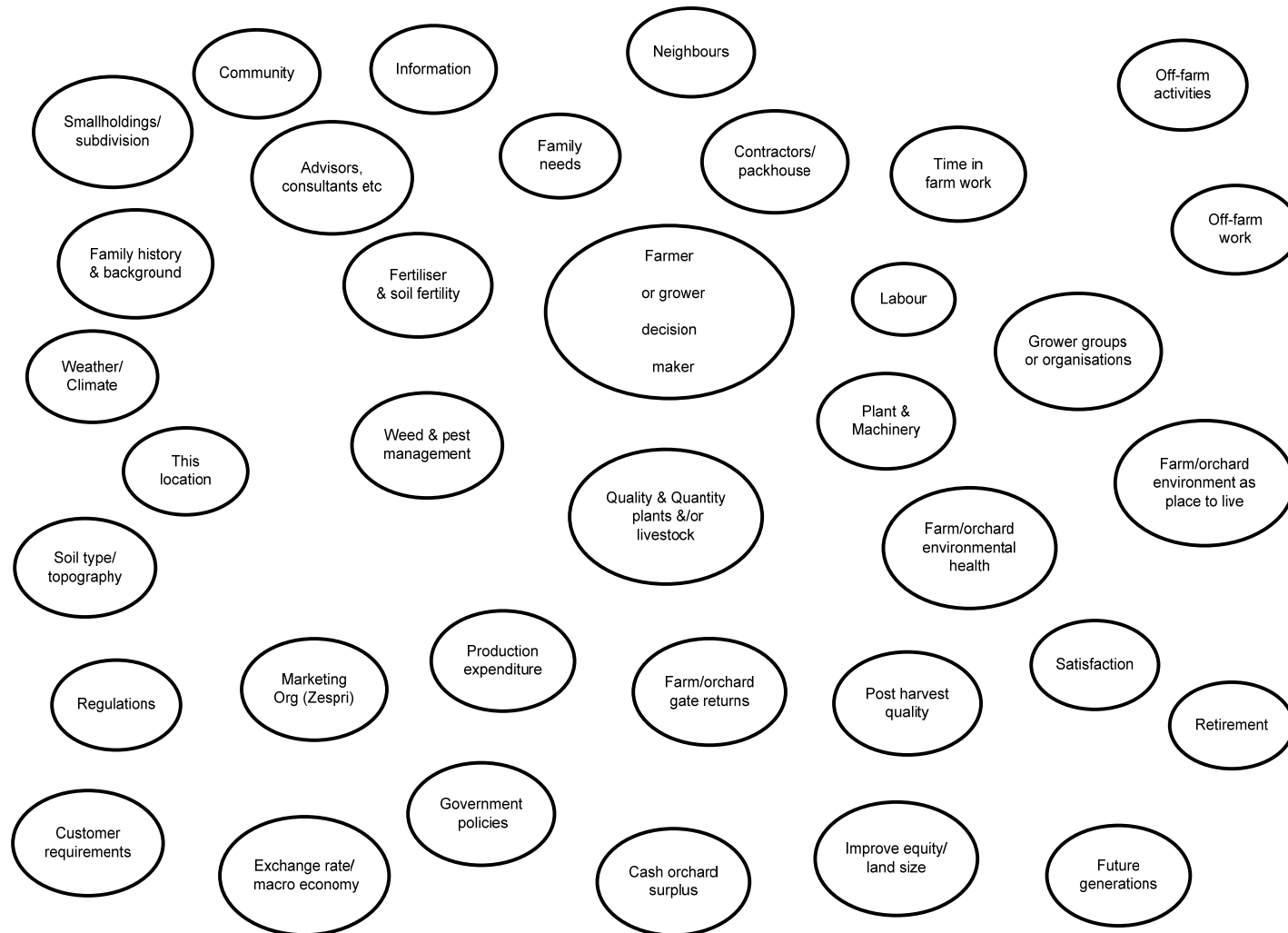
The results from this second pre-testing showed that the mapping was a difficult procedure for many farmers. While they were confronted with a number of factors in the conduct of farming, they did not consciously think of all the factors that comprise their farming system. As a result, the process of getting the list of factors was sometimes time consuming. Further, some farmers were good at drawing while others found it difficult. These observations suggested that farmers would respond better if they were presented with a set of factors so that the development of their causal map did not depend so much on bringing to mind factors and on drawing ability. Accordingly, the data from all 14 pre-tests were used to develop a generic map, without arrows, which included all the main factors. These were placed on a large sheet of paper in such a way that some of them were located close to others that they were typically connected to and which logically were closely related to. Inspection of the generic map shows that the on-farm factors are all located near to the decision maker. For example, the decision maker is likely to causally influence fertiliser and soil fertility. The idea was the respondents would begin their mapping by identifying factors that they considered relevant to their system and then connect these factors to other factors to reflect causal influence. By preparing a generic map with all the factors found in the pre-tests it would be possible to provide a comprehensive set. Any additional factors needed by a particular orchardist could be added in. Figure 1 shows the generic map.

The advantages of providing a generic map were that, as indicated above, it made it easy for those farmers not comfortable with drawing to express their view of their system on equivalent terms to those able to draw maps easily. It also overcomes the problem of very complicated maps, particularly those where the factors were added almost at random resulting in confusing connections between factors. Another benefit is that the generic map provided consistency in the naming of the factors. With Ozesmi and Ozesmi's (2003) method, it is possible to have idiosyncratic labels for very similar if not identical factors on each of two maps. The labelling gave a focus to the thinking of each farmer. Consistency is important where the goal is to make group maps by aggregating across groups. Uniformly labelled factors make this easy to do. We will return to a fuller evaluation of our modifications to FCM in the conclusion of this chapter. In the meantime we describe some further developments in our approach to causal mapping, followed by a description of the data generated from the mapping.

Providing a generic map could influence how participants respond to the causal mapping process. For example, the generic map necessarily put some factors close to others and this may have encouraged respondents to connect those that were close together. However, we found that participants retained the ability to connect factors in any way. Several participants connected factors that were not close together and this provides some supporting evidence of this ability. However, we do not know if all participants had this ability.

¹ We acknowledge Chris Perley's (Environment research team, Otago University) suggestion of these ideas.

Figure 1: The generic map



Pre-test with kiwifruit orchardists not involved in ARGOS

A final set of pre-testing with kiwifruit orchardists indicated the need for several amendments to the prepared generic map. The frequent addition of the two factors of marketing company/organisation and grower group/organisation by the orchardists showed that we needed to include them in the list of factors. Since there were so many arrows to and from the 'decision maker' factor we decided to enlarge this circle to give it a longer perimeter on which to attach arrows. The factor 'markets' was changed to 'gross market returns' and 'expenditure' to 'production expenditure'. In terms of the recording process, we found that the important factors could be ticked and important feedback factors could be underlined.

The questions asked at the end of the mapping were modified to include the following:

1. Which factors are most important? Please tick each one.
2. What are the important feedbacks to you as decision maker?
3. What are you trying to maximise? Minimise? What is at the heart of your system?
4. To what degree can the system change? Can you change it? Is the system likely to change? How resistant to change is it?
5. What are your main farming/growing goals?
6. How do your inputs/ha and cash orchard surplus/ha compare to other farms or orchards of a similar type to you (high, above average, average, below average, low)?
7. Has this process been of any benefit to you?

We also clarified that the scoring system was meant to be an indication of the strength of the causal connection between factors not a precise measure of it. We explained that we wanted an indication of whether the connection was of low (1,2 or 3), medium (4, 5 or 6) or high (7, 8, 9 or 10) strength. Most orchardists were reluctant to use the score of ten.

Introduction to, and instructions for, mapping

While the technical elaborations outlined above were important, a parallel set of innovations was occurring in the structuring of questions, focus and scale of the intended map. In particular, the early focus on situating a farm's activities in a wider ecosystem fell outside the general operating conceptualisation mobilised by most farmers. This was an interesting finding in itself, and will be returned to in the later discussion. Our response was to much more firmly focus on what the pre-test farmers considered their 'natural' terrain – the way in which farm management and decision-making operated within the multiple causal influences on a farm operation.

The interview began with a reminder that the first social objective interview had focused on vision and general goals rather than on management. We explained that in the current activity the focus was on management and how the orchardist handled all the factors that influence "... your managing of your farm or orchard". We explained that to do this we wanted them to draw a map. Then we explained that interviews with 14 farmers and orchardists had allowed us to prepare a draft map. The instruction was:

Please look at the draft map and make the appropriate changes to reflect your situation:

- Strike out any factor that does not apply and include any ones that need to be there.
- Add in or take out any arrows (they can be 1 or 2 directional).
- For each factor: what, if anything, influences this factor? What, if anything does this factor influence?

- Assign a measure of the causal strength of each arrow (1-10 scale).

Adaptations made during the first three interviews with ARGOS kiwifruit orchardists

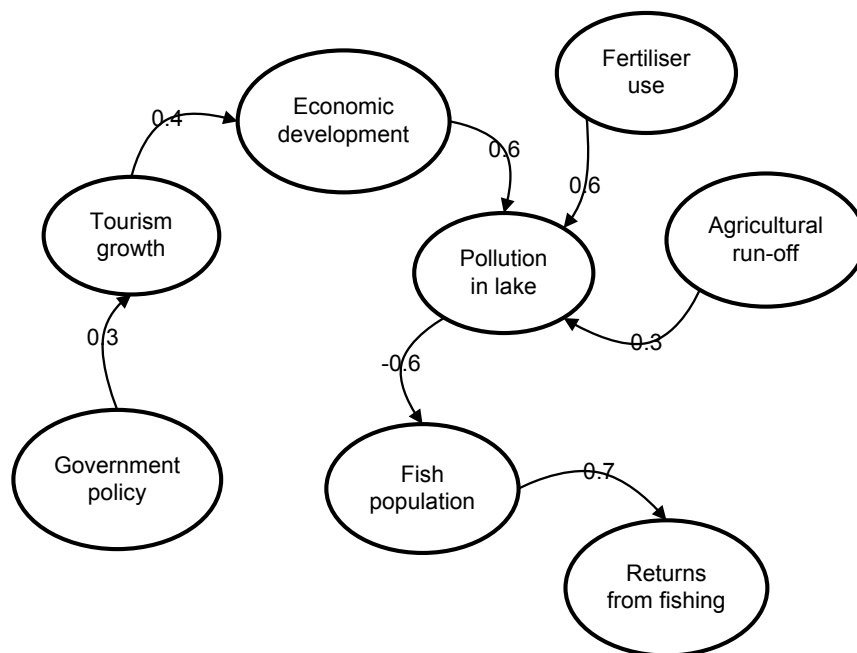
The initial responses to the generic map indicated the need for additional minor adjustment to it. For example, 'location' was changed to 'this location' to avoid confusion between the choice of location of an orchard and the actual location of the orchard in the study. 'Gross market returns' was changed to 'orchard gate returns', 'net income' to 'orchard surplus', 'marketing company' to include ZESPRI, 'weed and pest control' to 'weed and pest management', 'orchard gate returns' to include net earnings before tax, 'contractors' to include 'packhouses', 'smallholdings' to include 'subdivision' and 'farm/orchard environmental quality' to 'farm/orchard environmental health'. We also eliminated 'work-life balance' because, while it appealed to some orchardists, it was not always used and for some it was similar to 'time in farm work'.

We also learned to enquire about any given factor by asking: "What, if anything, does this factor cause?" and, "Is there anything else that this factor causes?" Then we asked: "What, if anything, causes this factor?" We attempted to apply this to all factors. In some cases the subjects 'took off' and started linking factors in a causal way, in other cases they preferred to be guided by the researcher. In one case where the subject did not easily draw arrows or numbers we did it for them following their directions. Initially, we asked the subjects to start anywhere to link factors with arrows, but after the first three cases we decided that the task was easier if we provided guidance to a definite starting point so we asked them to start with 'the decision maker'. We knew from our pre-testing that this was an important factor. If they did not take off from the decision maker and link to relevant factors and looked to us for guidance, we suggested that they consider the factors between the decision maker and cash orchard surplus in order to establish a core part of the orchard situation. In some cases this advice worked but often subjects who asked for guidance moved to other factors rather than work towards cash orchard surplus. In these cases we assisted by asking the key questions and then asking these of factors that had not been considered.

We found it repetitive to ask if there were more factors that a particular factor caused. We could not be sure that in merely being thorough, our enquiry was taken as a suggestion that there ought to be more connections. We explained that we were trying to be thorough and not wanting to lead the subjects. It remains possible that our questions may have elicited connections but if this did occur it is likely that they would receive a low score. For many of the connections, the subjects made them independently of our questions and they readily made connections to widely separated factors because they were driven by their knowledge of their situation. It was not that they looked at the factors on the generic map and the generic map stimulated them to respond. Rather, they drew on their knowledge of their situation to make the appropriate linkages. We are confident that the interview process allowed subjects to draw in the important linkages between factors relevant for the orchard.

After the first three cases we realised that an example of a simple causal map would be useful to outline the process before actually proceeding with the mapping. We prepared a simple map with eight factors (see Figure 2 below). This map was then integrated into a revised introduction to the causal mapping process, emphasising how we were moving from the general questions in the first interview to a specific focus on managing the factors associated with their orchard.

Figure 2: Example of a causal map



Policies developed during the second three interviews

An issue that developed in the second set of kiwifruit interviews was what do we mean by causal influence when we ask how does factor X relate to factor Y? Orchardists thought in terms of: (1) this is essential to that, (2) this is very frequent, or (3) this is a major component of this factor e.g., expenditure. If any one of these applies then the connection received a high score. But if the factor is essential does it get a high score? Just because an item of expenditure is a large item is it strongly causal? What about when labour strongly influences available time and this connects to them keeping a tidy orchard? Few made the connection from 'labour' to 'time in farm work'. If something like the weather is always there and you have little control over it is it therefore of low strength?

Our policy decision was to let the orchardist put in the number for his or her situation as it reflected all the elements of the connection. This means that the score is not a consistent measure of some objective factor but an overall assessment based on a variety of factors. In this sense the mapping is more of a qualitative method even though we take the numbers and use them in a quantitative way.

Another issue involved the tendency for participants to link two factors and overlook an obvious intermediate factor. For example, some participants said that ZESPRI was causally linked to fertiliser and soil fertility. What they meant was that ZESPRI influenced them and they, in turn, influenced fertiliser and soil fertility. We gently enquired about some of the links that might have 'jumped over' an important factor and let the participant explain what they meant. In most cases this enquiry led to a more thorough account of the situation and the full sense of the connections was drawn on the map. If our enquiries did not lead to any further insight we left the original connection intact. In effect, we interacted with the respondent to achieve a fuller understanding of causal connection rather than accept a more superficial linkage of factors. This process reflects that the research was an interaction between researcher and participant rather than a hands-off recording of linkages. Such an interactive approach is a normal part of qualitative research where the growing knowledge of the researcher influences the nature of interactions with subjects later in the research process.

A final observation was that the ease with which an orchardist was able to make the connections between the factors depended on how involved they were in actual on-orchard production. There was a tendency for those who used contractors to find the causal mapping more difficult.

2.5 Analysis of map data

Each map drawn by an individual was reproduced as a digital map using the Microsoft Visio drawing programme, and the map data were entered into an Excel spreadsheet. The spreadsheet consisted of a matrix of 36 by 36 factors whereby the row factor was taken to cause the column factor. All the cells, except the diagonal, were available to be used. This means that in the case of a bidirectional or feedback arrow, one number was entered on one side of the matrix (X caused Y) and another number entered on the other side (Y caused X). For some bidirectional arrows the weightings were different for each direction.

Characteristics of the matrix were identified by summing column totals (indegree – measuring the combined weight of arrows leading to that factor, and row totals (outdegree – measuring the combined weight of arrows leading away from that factor. These two numbers were added together to provide a measure of the overall importance of that factor in the map or, as it is known in causal mapping, the centrality of the factor. These data were then used to identify the numbers of transmitter factors (those with arrows only leaving the factor), receiver factors (those with arrows only entering the factor) and ordinary factors (arrows both leaving and entering). A number of other map characteristics of the group map were derived, as shown in Table 1.

Table 1: Characteristics of the Causal Maps

Count	Derived Factor	Name
Total factors (N)		
Omitted factors		
Transmitter factors		
Receiver factors	Ratio receivers/transmitters	Complexity
Ordinary factors		
Connections (C)	Average connections/factor - C/N^2	Density
		Hierarchy Index
Bi-directional arrows		

In order to determine which factors were basically transmitter or receiver factors, t-tests were carried out on the difference between the outdegree and the indegree scores, both for the means of the values assigned to these connections and the frequency or number of those connections. If a greater value had been placed on the connections of a factor **to** other factors rather than the value placed on the connections **from** other factors then this would be predominantly a transmitter factor. If the value was negative, indicating that a greater value had been placed on the connections into a factor, then this factor would be a receiver factor. If this difference was not significant then the factor could be considered to be both a receiver and a transmitter.

The map data were aggregated for all 36 orchards to prepare the group map data. This provided a description of the 36 orchardists and the relationship between the factors that they considered important in managing a farm or orchard. The focus was on the mean scores given to the arrows from each factor to another one and on the frequency with which arrows were used. The group maps were prepared based on average scores. Then the group map data were analysed by panel, each panel consisting of 12 Gold, 12 Green and 12

Organic orchardists respectively. We used both score data and frequency data. The former are based on the total score for each factor (the total value given to all the arrows entering or leaving a factor on the map), while the latter are based on number of times a link was made between a factor and all the other factors. Preliminary analysis of individual cells in the matrix for each panel was unsuccessful because there were too many cells with zeros. We then worked with indegree, outdegree and centrality for both means and frequencies. ANOVAs were carried out on these scores and frequencies using orchard location as a blocking factor and panel as the treatment factor, as envisaged in the original ARGOS design. In this way significant differences between the three panels could be identified. ANOVAs were also carried out on the map characteristics identified in Table 1.

The above analyses were supplemented by considering the responses to two of the questions asked of all participants at the end of the interview. On completion of their causal map each person was asked to show which of the factors were the most important and these were marked with a tick. T-tests were carried out to test whether or not a factor which was considered important was given a higher value in its connections to other factors, whether that factor was given more connections to other factors, and/or whether on average that factor received a higher strength per linkage.

Participants also indicated the factors that were most important as feedbacks to them by underlining them. These were the factors they watched most carefully. In some cases there were factors that were identified as important as feedbacks but which did not have a causal arrow connecting to the decision maker. During the last half of the kiwifruit interviewing this was discussed with the orchardist and as a result the orchardist put in the arrow to the decision maker. In order to have a consistent set of data, for the earlier cases where a factor was identified as important as a feedback but not linked to the decision maker, an additional arrow was inserted into the causal map and a score of eight was assigned since the farmer had said that it was an important feedback. In many cases the adjusted arrow was from quality and quantity of production to the decision maker. The result of this adjustment slightly increased the indegree and centrality for the decision maker and for quality and quantity of production. ANOVAs were carried out on the adjusted data.

2.6 Conclusion

Cognitive mapping appears to be a useful method for recording how people perceive the causal linkages within systems in which they are participants. As developed by Ozesmi and Ozesmi (2004), it allows detailed and personal ideas to be recorded in the individual maps prepared by each person but, in addition, it uses quantitative data to characterise the maps in a variety of ways. It is a hybrid method but one still strongly grounded in individual subjectivity since participants are completely free to draw their own maps and identify and label their own factors. Further, FCM allows for the creation of a group map for a group of people, typically by recording the views of a number of people about one system. Evaluation of FCM shows that there are some issues relating to mapping, the main one being the issue of how to capture valid information from a range of lay/expert participants in systems. However, these issues do not detract from the advantages of FCM in providing a means to document how people see a system working and the means to analyse these perceptions in quantitative ways. Particularly useful is the ability to combine individual maps and produce a group map. Not strongly developed by Ozesmi and Ozesmi (2004) is the application of FCM to multiple sites (meta analysis) but this aspect is very relevant our research objectives. In mapping, the main aim is to gain insight into how systems are perceived to work and using this knowledge to solve problems associated with the system.

While Ozesmi and Ozesmi (2004) directed their attention at broad eco-systems and their participants, our pre-testing refined the scope and scale of questions to concentrate on the

management decisions of farmers within farming systems. We responded to the findings of early pre-testing and modified the mapping process to make it easier for farmers. This process introduced both advantages and disadvantages. The use of a generic map provided a comprehensive set of factors, while allowing for the insertion of new factors, and made the task easier for farmers not adept at drawing. Further, by using the set of factors, each factor had a consistent label and it was possible to easily make group maps by aggregating the individual map data across groups. However, the presentation of the generic map may have had some influence on how participants responded. In particular, the arrangement of the factors on the generic map, guided by our emerging understanding of the system and designed to minimise overlapping arrows and thereby minimise potential confusion, may have influenced responses. This issue will be the subject of continual re-evaluation in future deployment of this method. For the purposes of this first body of research, we used a consistent generic map and if there was any influence, this was uniform for all participants.

Results from pre-testing also led to the implementation of a number of innovations and policies. Amongst these was the decision to enlarge the circle which contained the factor called 'decision maker', to guide participants to start with decision maker, and the decision to enquire about linkages between factors that appeared to overlook an intermediate factor. These decisions are consistent with qualitative research in which the researchers' increasing understanding of the subject matter influences how they approach the research and participants in later phases of the research process. It was not solely the decision of the researchers to make the decision-making of farm managers the central focus of the enquiry, rather, this was strongly conditioned by the initial pre-testing of the method. For all the farmers, this was a uniformly important factor. Presenting factors in an apparently neutral way is not easy to do since any presentation of factors involves some degree of framing in the way that they are presented. In our case our framing reflected the way that participants thought. We also found that orchardists responded well to the generic map in the sense that it did allow them to explain and show which factors were part of their system and how they were linked. It was, however, still a demanding job to do since it required them to think about all the factors rather than those which were in the forefront of their minds at the time of interview.

The innovations and developments in our use of causal mapping have moved the method further away from a purely qualitative approach. Our application, while still largely qualitative, does not let participants have free reign to draw their own maps using their own personally selected factors. Consequently, some of the individual richness is lost. Accordingly, researchers seeking to record such richness would need to consider how best to proceed and may be better served with FCM as specified by Ozesmi and Ozesmi (2004). However, they need to be aware that any attempt to form group maps from such idiosyncratic data will require the researcher to make decisions about the similarity of factors. Researchers seeking to aggregate map data across groups would be better served with causal mapping as we have developed it here.

While causal mapping shows promise, as with any method, it has a number of limitations (Bryson et al., 2004). The process is limited by the map being a representation of a system. It may or may not be how the system works and it may not be the final version of how a system is seen. Mapping as a research technique may not appeal to some people. There are trade-offs in what it provides. For example, getting a good group map means that some individual-level detail is lost. Likewise, the maps are very sensitive to the scale and scope of questions being asked. Asking farmers to explain causality in whole ecosystems led to a map that emphasised farm management and decision making.

Chapter 3

Kiwifruit Results

3.1 Introduction

In this chapter, data are presented for the group map for all 36 orchardists followed by the group map data for each panel. One of the main ways we use to assess maps is by measuring the centrality of factors. Centrality measures a factor's importance by summing the data for arrows going into and out from the factor. It must be noted that centrality is a measure of how a factor stands in relation to all the other factors. It remains the case that there may be individual connections between factors that can be decisively important in the causal map of the system, and links between several factors that demonstrate important flow-on influences. (The latter are difficult to analyse in any meaningful way). The reader is warned that this chapter is complex at times because the data are themselves quite complex. We have had to explore a number of directions of analysis of the map data in order to do justice to the complexity of the systems involved. Readers less interested in the details may proceed to the conclusion where the key findings are summarised before they are discussed.

3.2 Group map data for all 36 orchardists

Each participant took about 60 to 80 minutes to complete their causal map. On average, they included 31 out of the total of 36 factors in the generic map. Seven participants included additional factors but four of these additional factors were provided by one person.

Once each individual map had been completed the data contained in it were then entered into an Excel spreadsheet in the form of a 36 by 36 matrix. When the data for all 36 cases had been entered it was possible to create an equivalent data matrix for the group map by calculating the average score for each cell in the matrix (Appendix 1 shows the kiwifruit group map data). These average scores then formed the basis of further calculations.

Since the group map is the product of all 36 maps it contains many causal connections between many factors. That is, even if only a few people or even one person made a connection between two factors, it would show up in the group map, albeit with a low average score. Accordingly, all the factors are ordinary factors, that is, having arrows entering and leaving the factor. There were no pure transmitter or pure receiver factors, that is, factors having arrows only leaving or only entering the factor. The complete matrix for the group map data shows that participants made a total of 104 separate connections between factors, considerably short of the theoretical maximum of 36 times 35 or 1,260 connections, but still rather too many to represent easily on a single map (see later). The average number of connections was 55.

In this section of the report the data are presented by first focusing on the group map data and then focusing on the group map generated by these data.

Map data

Table 2 shows the core descriptive data derived from the average scores in the kiwifruit group map. These data include the matrix column total or indegree (average of the total of the values given to arrows entering the factor), matrix row total or outdegree (average of the

Table 2: Average strength of linkage for the kiwifruit group map

Factor	Indegree (influence from other factors)	Outdegree (influence on other factors)	Centrality (overall value of factor)
The decision maker	94	73	168
Quality and quantity of production	39	23	61
Orchard gate returns	26	16	42
Marketing organization (ZESPRI)	21	21	41
Production expenditure	29	9	38
Contractors and packhouse	10	27	37
Cash orchard surplus	17	14	31
Satisfaction	28	2	30
Fertiliser and soil fertility	9	16	25
Weed and pest management	9	14	23
Labour	7	14	21
Farm/orchard environmental health	10	11	20
Post harvest quality	12	8	20
Regulation	7	12	19
Time in farm work	12	8	19
Weather/climate	2	15	17
Farm/orchard place to live	8	8	15
Improve equity/land size	8	7	15
Plant and machinery	6	8	14
This location	4	10	13
Advisors, consultants	4	10	13
Soil type/topography	2	10	12
Customer requirements	1	11	12
Exchange rate, macro economy	2	10	11
Family needs	5	6	11
Government policies	1	9	10
Information	2	8	10
Off-farm activities	7	3	10
Neighbours	2	4	7
Grower groups or orgs	1	5	6
Off-farm work	4	2	6
Retirement	6	0	6
Future generations	3	1	5
Community	1	3	4
Smallholding/subdivision	1	2	4
Family history and background	0	2	3
Overall average	11.1	11.1	22.1

Note: the last column may not be the precise sum of the first two columns because of rounding.

total of the values given to the arrows leaving the factor) and the sum of these two figures, the centrality, for each factor. The factors are listed in order from highest to lowest centrality.

The average centrality for all the factors² was 22. The factor with clearly the highest centrality was the decision maker with an average score of 168. For this factor the indegree was slightly higher than the outdegree indicating that other factors influenced it more than it influenced other factors. Next in order of centrality were quality and quantity of fruit and/or livestock with an average of 61 (indegree higher than outdegree), orchard gate returns with 42 (indegree higher than outdegree) and ZESPRI with 41 (indegree equal to outdegree). Other important factors were production expenditure with 38 (indegree higher than outdegree), contractors/packhouse with 37 (indegree lower than outdegree), cash orchard surplus with 31 (indegree higher than outdegree) and satisfaction with 30 (indegree higher than outdegree).

These factors with high centrality (as shown by having a score of 30 or above which is well over the average of 22) show that at the heart of orcharding is the decision maker with production, financial aspects (represented by returns, expenditure and orchard surplus), the two organisations with influence over the kiwifruit industry (ZESPRI and contractors/packhouse), and satisfaction. These important factors with high centrality tend to have a high indegree value, meaning that they were seen to be influenced by other factors rather than as influencing other factors.

Other important factors with about average centrality (19-25) were fertiliser and soil fertility with 25 (outdegree higher than indegree), weed and pest management with 23 (outdegree higher than indegree), labour with 21 (outdegree higher than indegree), orchard environmental health with 20 (similar indegree and outdegree), post harvest quality with 20 (indegree higher than outdegree), regulation with 19 (outdegree higher than indegree) and time in farm work with 19 (indegree higher than outdegree). Most of these factors had higher outdegree than indegree indicating that they were seen to influence other factors.

The remainder of the factors had low centrality scores. These were often background or contextual factors such as the weather or the exchange rate/macro-economy or goals to be achieved such as retirement or future generations. Those with higher indegree were goals such as improve equity or retirement. Lowest centrality scores were received for some background factors such as community (4), smallholding/subdivision (4) and family history and background (3). Again, most of these factors had higher outdegree than indegree indicating that they were seen to influence other factors. It would appear that factors with high centrality necessarily have a greater number or weight of factors influencing it.

So far the analysis has been based on the 1-10 score for the causal connections between factors. However, importance of factors can be assessed by considering how often factors were connected. It may be, for instance, that two factors were linked with a high score but not very often or, conversely, two factors were linked by a low score but this was done very frequently. Table 3 shows the average frequencies of the number of links made to and from the factors. The table presents the factors in the same order as in Table 2 and the last column shows the order based on frequency for centrality. From these data it can be seen that the decision maker was the most important factor with an average of nearly 25 links made to other factors – 14 of which were other factors that impacted on the decision maker and 11 in which the decision maker impacted on another factor. From there on, the order of the factors by number of connections to other factors is largely similar to that of Table 2. The data are showing similar patterns of connection between the factors in the group map as measured by strength of connection and frequency of connection.

² The factors are more correctly known as variables since they have varying levels of importance in a causal map. We continue to use the term 'factors' since this was how the components of the maps were thought of by participants and was the word used with the participants.

Table 3: Average frequency of linkages for the kiwifruit group map

Factor	Indegree	Outdegree	Centrality	Order
The decision maker	14.2	10.7	24.9	1
Quality and quantity of production	5.1	2.8	7.9	2
Orchard gate returns	2.8	2.7	5.5	4
Marketing organization (ZESPRI)	3.3	1.8	5.0	6
Production expenditure	4.6	1.1	5.7	3
Contractors and packhouse	1.5	3.8	5.3	5
Cash orchard surplus	2.1	1.8	3.8	8
Satisfaction	3.7	0.3	4.0	7
Fertiliser and soil fertility	1.3	2.2	3.4	10
Weed and pest management	1.3	2.3	3.5	9
Labour	1.0	1.9	2.8	12=
Farm/orchard environmental health	1.6	1.1	2.7	14=
Post harvest quality	1.4	1.6	3.0	11
Regulation	1.6	1.1	2.8	12=
Time in farm work	1.1	1.6	2.7	14=
Weather/climate	0.2	1.9	2.1	19
Farm/orchard place to live	1.0	1.0	2.0	20
Improve equity/land size	0.8	1.8	2.6	16
Plant and machinery	0.8	1.5	2.3	17
This location	0.5	1.3	1.8	21
Advisors, consultants	0.6	1.6	2.2	18
Soil type/topography	0.2	1.4	1.5	25
Customer requirements	0.2	1.4	1.6	24
Exchange rate, macro economy	0.2	1.2	1.4	27=
Family needs	0.8	0.8	1.6	22=
Government policies	0.3	1.4	1.6	22=
Information	0.3	1.1	1.5	25=
Off-farm activities	0.9	0.4	1.4	27=
Neighbours	0.6	0.9	1.4	27=
Grower groups or orgs	0.3	0.9	1.2	30
Off-farm work	0.5	0.4	0.9	31=
Retirement	0.8	0.1	0.9	31=
Future generations	0.5	0.2	0.7	34
Community	0.3	0.6	0.9	31=
Smallholding/subdivision	0.3	0.4	0.6	35
Family history and background	0.1	0.4	0.5	36
Overall mean	1.6	1.6	3.2	

Note: the third column may not be the precise sum of the first two columns because of rounding.

Table 4 shows strength per linkage data derived from Tables 2 and 3 by dividing the average strength of linkage by the average frequency of linkages. In effect, Table 4 portrays a different perspective on the data by demonstrating that some factors may have had few connections but that those connections were given a high value by participants, and thereby would have a high strength per linkage. The factors that stand out with high values, as shown in bold in Table 4, are orchard gate returns, cash orchard surplus, exchange rate/macro economy, customer requirements and at fifth equal, quality and quantity of production and weather/climate. With these data the decision maker is less important and,

further, its outdegree is slightly higher than its indegree, unlike in Tables 2 and 3. These data tell us the factors that were connected most strongly to the others. For example, any connection from orchard gate returns (outdegree) was given a higher value (8.9) on average than any other factor implying that orchard gate returns influenced the factors it connected to more strongly than any other factor did. Similarly, improve equity/land size has an indegree strength per linkage of ten, implying that any connection made to it had maximum causation. Basically, Table 2, 3 and 4 show three different way of measuring importance: in terms of total influence, number of the ways influenced or influenced by, and strength of influence when it was scored.

Table 4: Strength per linkage for the kiwifruit group map

Factor	Indegree	Outdegree	Centrality	Order
The decision maker	6.7	6.9	6.7	24
Quality and quantity of production	7.5	8.2	7.8	5=
Orchard gate returns	8.1	8.9	8.4	1
Marketing organization (ZESPRI)	7.5	7.6	7.5	9=
Production expenditure	6.3	8.1	6.6	25=
Contractors and packhouse	6.5	7.2	7.0	17=
Cash orchard surplus	9.5	6.1	8.2	2
Satisfaction	7.6	7.4	7.6	8
Fertiliser and soil fertility	7.6	7.1	7.3	12
Weed and pest management	7.2	6.0	6.4	27=
Labour	7.5	7.5	7.5	9=
Farm/orchard environmental health	6.9	6.8	6.9	21=
Post harvest quality	7.3	7.9	7.5	9=
Regulation	6.7	7.0	6.9	21=
Time in farm work	7.2	6.8	7.0	17=
Weather/climate	7.4	7.8	7.8	5=
Farm/orchard place to live	7.8	7.6	7.7	7
Plant and machinery	7.1	5.3	5.9	30
This location	7.5	7.2	7.0	17=
Advisors, consultants	5.5	6.2	6.0	29
Soil type/topography	7.1	7.1	7.1	14=
Customer requirements	7.0	8.1	7.9	4
Improve equity/land size	10.0	3.9	5.8	31
Exchange rate, macro economy	8.3	8.0	8.1	3
Family needs	7.0	7.2	7.1	14=
Government policies	3.8	6.9	6.4	27=
Information	7.3	6.6	6.8	23
Off-farm activities	7.4	6.6	7.2	13
Neighbours	4.2	4.9	4.6	35=
Grower groups or orgs	4.0	5.5	5.1	34
Off-farm work	7.3	5.9	6.6	25=
Retirement	7.1	8.0	7.1	14=
Future generations	7.0	7.0	7.0	17=
Community	4.2	4.8	4.6	35=
Smallholding/subdivision	5.1	6.1	5.7	32
Family history and background	8.5	4.9	5.3	33
Overall mean	6.9	6.8	6.8	

Note: the third column may not be the precise sum of the first two columns because of rounding.

Overall, Tables 2, 3 and 4 demonstrate which factors were regarded as having the greatest value and number of links compared to other factors. Table 2 shows that, overall, the decision maker, quality and quantity of product, orchard gate returns, marketing organization (ZESPRI), production expenditure, contractors and packhouses, cash orchard surplus and satisfaction had the greatest overall value placed on their connections to and from other factors. In addition, only contractors and packhouse among the high scoring factors had more of an influence on other factors, while the decision maker, quality and quantity of production, orchard gate returns, production expenditure and satisfaction were more influenced by other factors. (See Table 5, which divides the factors into transmitters and receivers).

Table 3 shows that the same top ten as in Table 2 have the most connections to and from other factors (with slight changes within that ranking order), which demonstrates mainly that the frequency data reflects the means data. The table is also similar in that most of the top eight have high indegree but there are some differences. Orchard gate returns has a similar indegree and outdegree score, while ZESPRI has higher indegree compared to Table 2. Contractors and packhouse has consistently high outdegree in both tables. These results show that orchardists assigned weight and frequency of arrows in similar ways.

Table 4, as mentioned before, shows these factors in quite a different light. Of the factors given the most value per connection, only four still featured in the top eight according to Tables 2 and 3 - quality and quantity of production, orchard gate returns, cash orchard surplus and satisfaction. Factors like exchange rate, customer requirements, weather and farm/orchard as a place to live, though they had fewer connections to or from other factors, were given a greater value per connection than many of the other more overall dominant factors. Accordingly, some of the higher rated factors in terms of the data in Tables 2 and 3 have a lower rating in this table. For example, decision maker, production expenditure and contractors and packhouse are rated much lower. Those impacted most (in terms of value per connection) by other factors (i.e., high indegree) were improve equity/land size, cash orchard surplus, family history and background (only two orchardists made this connection but they placed a high value on it), exchange rate and orchard gate return. Orchard gate return, quality and quantity of product, production expenditure, retirement, customer requirements and exchange rate had high influence on other factors even though the first two also have some of the highest strength and number of connections to other factors. Overall, Table 4 serves to show the effect particular individuals have had on a factor by giving it a high value per connection. It may be that people included these factors but when they did they gave them a higher linkage value.

Another way of considering these data is to see which factors are predominately transmitters or receivers³. Significant differences between the outdegree and indegree data for both means and frequencies were found, and the results of this analysis are shown in Table 5. The numbers are derived from the difference between the outdegree value and the indegree value, so that if the number is positive (high outdegree), the factor is predominately a transmitter factor and if the number is negative (high indegree) the factor is predominately a receiver factor. This analysis is a way of separating out the transmitter and receiver factors, and identifies ordinary factors, those factors that do both equally. However, as has been pointed out earlier, all factors have transmitter and receiver components. Generally, the pattern of results for the means and frequencies is similar. The data in Table 5 correspond to the results in Table 2 and show that among the factors with high indegree and outdegree means (greater than ten), there are five factors which are high-scoring receiver factors, but only two factors, contractors/packhouse and weather/climate, are high-scoring transmitter factors. In addition,

³ To be true to Ozesmi and Ozesmi's (2003) description of transmitters and receivers, such factors should be totally outdegree or indegree respectively. In this respect all our factors are ordinary factors.

Table 5: Division into transmitter and receiver factors

Factor	Difference: out degree – in degree (means)	Difference: out degree – in degree (frequencies)
Transmitters (high outdegree)		
Contractors and packhouse	17.2 ***	2.2 ***
Weather/climate	13.4 ***	1.7 ***
Customer requirements	9.8 ***	1.2 ***
Soil type/topography	8.3 ***	1.2 ***
Government policies	8.3 ***	1.1 ***
Exchange rate, macro economy	7.8 ***	1.0 ***
Labour	6.6 ***	0.9 ***
Advisors, consultants	6.3 ***	0.9 ***
Fertiliser and soil fertility	6.1 ***	0.9 ***
This location	6.0 ***	0.9 ***
Information	5.1 ***	0.8 ***
Weed and pest management	4.4 **	1.0 ***
Regulation	4.4 **	0.6 **
Grower groups or orgs	3.6 ***	0.6 ***
Neighbours	1.8 *	0.3 *
Family history and background	1.6 **	0.4 ***
Transmitters and receivers (ordinary factors)		
Plant and machinery	2.4	0.7 **
Community	1.3	0.2
Farm/orchard environmental health	1.2	0.2
Smallholding/subdivision	1.1	0.1
Family needs	0.5	0.1
Farm/orchard place to live	0.0	0.0
Marketing organization (ZESPRI)	-0.2	-0.1
Off-farm work	-1.4	-0.1
Improve equity/land size	-1.9	0.9 ***
Future generations	-1.9	-0.3 *
Post harvest quality	-2.6	-0.4 *
Cash orchard surplus	-3.5	-0.3
Receivers (high indegree)		
Time in farm work	-3.9 **	-0.5 *
Off-farm activities	-3.9 ***	-0.5 **
Retirement	-5.3 ***	-0.8 ***
Orchard gate returns	-10.8 ***	-1.5 ***
Quality and quantity of production	-15.9 ***	-2.4 ***
Production expenditure	-19.4 ***	-3.4 ***
Decision maker	-20.9 ***	-3.5 ***
Satisfaction	-25.6 ***	-3.4 ***

Note: the asterisks indicate the level of significance of the t-test which tested if this difference was significantly different from zero. * implies significant at the 5% level, ** significant at the 1% level, and *** significant at the 0.1% level.

the data show how the other factors rate as transmitters or receivers. For example, customer requirements, soil type/topography, government policies and exchange rate/macro economy are the main additional transmitter factors. Some of these factors were identified above as having high strength per linkage.

Supplementary map data

As mentioned in the methods chapter, after completing their causal map participants were also asked to mark the factors they considered were of most importance. We asked this question at the end of the interview as another way of assessing importance of factors. We expected that this overview question, in effect recording a vote for each factor, would confirm the mapping results. However, the voting did not closely match the mapping.

The fourteen factors voted on were, in order from highest frequency, cash orchard surplus and quality and quantity of product (each with 18 orchardist votes), satisfaction, orchard gate return, and family needs (each with 10), contractors (9), labour and orchard environmental health (each with 8), fertilizers and soil and marketing (6), the decision maker (5), production expenditure (4), advisors (3) and weather (2). Note that decision maker received only five votes yet it was the most important factor in the map in terms of centrality. When the centrality scores, number of connections and strength per linkage were compared to the vote data, only five factors out of the fourteen used were consistent. In other words, their scores from the maps matched the votes. These factors were cash orchard surplus, satisfaction, family needs, advisors and weather.

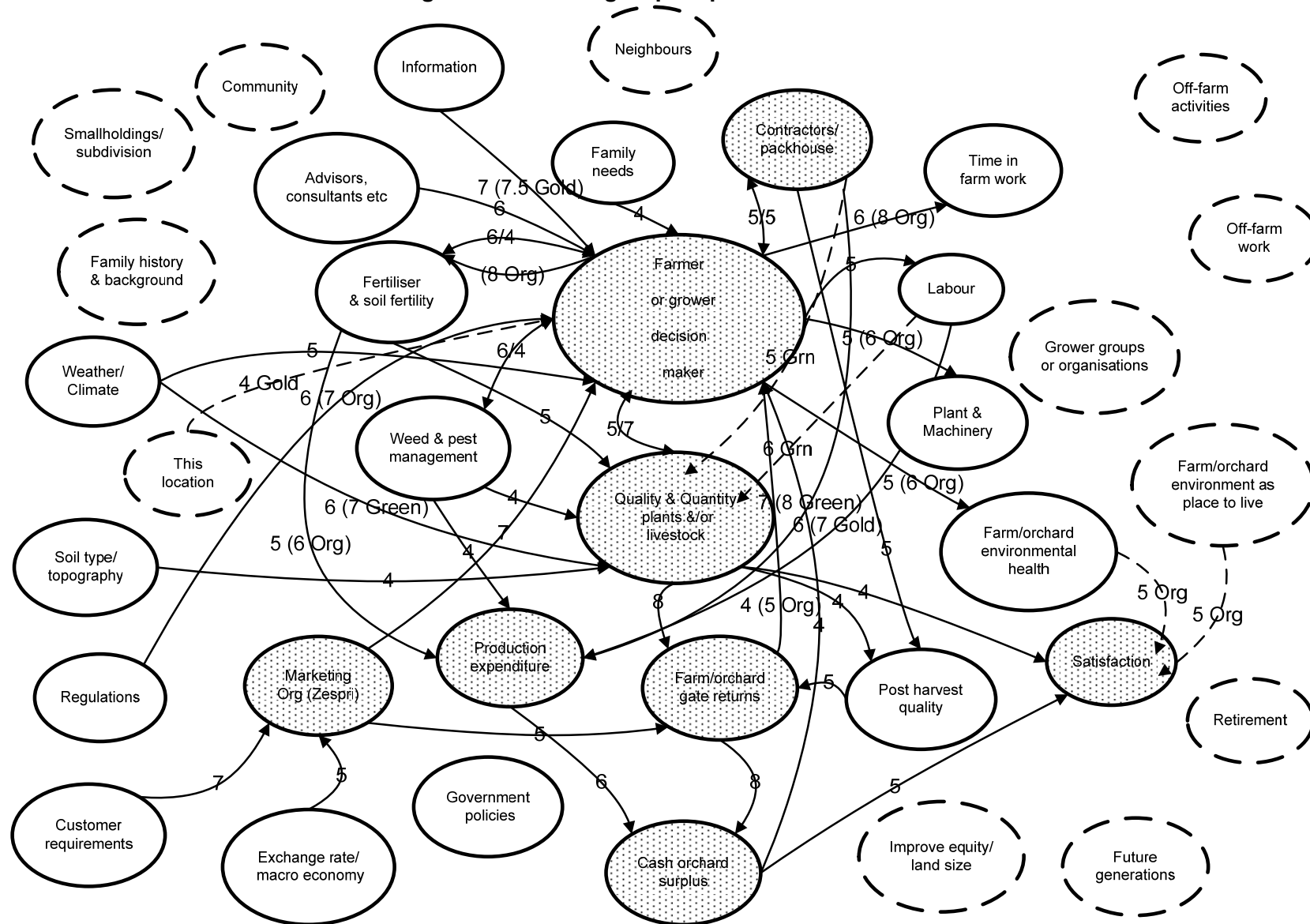
The differences occurring here between factors voted most important by participants and how they connected the factors on their maps, indicates that the voting process generated quite a different perception of the orchard system. The two processes were quite different. The mapping was a step-by-step analysis of all the relevant factors in their orchard system, while the second was an overall global assessment. In effect the voting was an attempt to rate the importance of each factor in comparison to other factors but without any reference to how the rating would be done. In the earlier mapping, the importance of each factor was determined by its relationship to other factors taking into account a variety of possible dimensions.

Group map

The centrality scores show which factors are important but they do not show, in detail, how all the factors were linked. To show linkages, we need to inspect the matrix of data and use these data to insert arrows into the original 'blank' generic map - the map with unconnected factors. However, the full group map has linkages between all factors and is difficult both to present and to interpret. To simplify the group map we tried some arbitrary minimum scores to see at which point the map appeared to show the main causal linkages. Even with a score of three and over the map was quite complex with only five factors not having any linkages. Using a score of five or over gave a map that was easy to comprehend but it omitted an important connection between cash orchard surplus and the decision maker. Using a score of four or more was suitable for showing the important connections without getting overwhelmed with connections, and this map is the main one we have chosen to present here. Note that the causal connection score from one to ten was explained to the orchardists to indicate that from one to three meant 'low', four to six meant 'medium' and seven to ten meant 'high'. Therefore an average score of four indicates a medium level of causal connection.

The derived group map is shown in Figure 2. The factors with above average centrality scores are shaded and the factors with no connection are indicated with a hatched circle. Generally, the map shows most of the factors are connected in some way with a concentration of arrows on the decision maker. Where two factors each influence each other a bi-directional arrow is used, and the two numbers on such lines are arranged so that the

Figure 3: Kiwifruit group map with scores of four or more



number nearest a given factor indicates the strength of connection to that factor. All the bi-directional arrows connect to the decision maker. The map also shows some connections as hatched lines that will be discussed in the next section, which focuses on panel differences.

Starting with decision maker, the map shows that it is influenced by many factors including: weather/climate (5), regulations (6), ZESPRI (7), cash orchard surplus (4), orchard gate returns (4), information (7) and advisors/consultants (6). In addition, some of the closer factors influence the decision maker, such as family needs (4), fertiliser and soil fertility (4), weed and pest control (4), quality and quantity of production (5) and contractors and packhouse (5). In turn, decision maker influences fertiliser and soil fertility (6), weed and pest management (6), quality and quantity of produce (7), contractors and packhouse (5), labour (5), plant and machinery (5), orchard environmental health (5), and time in farm work (6). In general, the factors linked to decision maker with bi-directional arrows have a higher score from the decision maker to the other factor, suggesting that the decision maker is having the stronger influence in these interactions. The exception is the link to contractors and packhouse which is weighted equally suggesting that this factor is seen as having relatively more influence on the decision maker.

The other major factors beyond the decision maker are causally influenced as follows. ZESPRI is influenced by customer requirements (7) and the exchange rate (5). In addition to decision maker, quality and quantity of production is influenced by weather and climate (6), soil type and topography (4), fertiliser and soil fertility (5) and weed and pest management (4). Production expenditure is influenced by fertiliser and soil fertility (5), weed and pest management (4), contractors and packhouse (7) and labour (6). Orchard gate returns are influenced by ZESPRI (5), quality and quantity of production (8) and post harvest quality (5). Cash orchard surplus is influenced by production expenditure (5) and orchard gate returns (8). Both quality and quantity of production (4) and contractors and packhouse influence post harvest quality (5), and post harvest quality influences orchard gate return (6). Finally, quality and quantity of production and cash orchard surplus influence satisfaction (4, 5).

In summary, the main links (score of four or above) in the group map show that the orchardist as decision maker is influenced by weather and climate, regulations, customer requirements via ZESPRI, advisors and information, family needs, contractors and packhouses, orchard gate returns and cash orchard surplus. As decision makers, they are also influenced by two immediate factors of production such as fertiliser and soil fertility, weed and pest management, and by quality and quantity of production. Decisions then influence all the factors of production, including contractors/packhouse, but from these only fertiliser and soil fertility and weed and pest management have a link of four or more to quality and quantity of production. The other influences on quality and quantity of production are the decision maker, weather and climate and soil type and topography. From production comes orchard gate returns although this is influenced by two other factors beyond direct control of the orchardist, ZESPRI and post-harvest quality, the latter influenced by the packhouse. Cash orchard surplus is driven by orchard gate returns and production expenditure which, in turn, is influenced by four factors of production: fertiliser and soil fertility, weed and pest control, labour and contractors and packhouse. Satisfaction is derived from cash orchard surplus and from quality and quantity of production. There are only two other important linkages beyond the ones just mentioned and these are from the decision maker to time in farm work and to orchard environment health. While the full group map shows a rich and interesting picture, the causal connections just highlighted demonstrate the key structural elements of the map.

One of the advantages of causal mapping is that the maps are representations of dynamic systems. These systems can have patterns of causality that include circuits of causal

connection⁴. For the kiwifruit causal map, there are four main circuits where there are a series of linkages that connect into a circle. To simplify their presentation we start with decision maker, which is included in all circuits. First, there is a production circuit which includes three feedbacks to the decision maker. It starts with the decision maker, and then works through fertiliser and soil fertility and weed and pest management to quality and quantity of production. From there it continues to orchard gate returns and then to cash orchard surplus and from each of these there is a feedback to the decision maker. Second, there is another production-related circuit with an emphasis on quality going from the decision maker via contractors/packhouse to post harvest quality to orchard gate returns. The circuit is completed with the feedback from orchard gate returns to decision maker. Third, there is an expenditure circuit which simply links the decision maker to all factors of production and then to production expenditure and cash orchard surplus. The circuit is completed with the feedback from cash orchard surplus to the decision maker. Finally, there is an important circuit that is incompletely specified in the group map but implied by it. It is from decision maker to quality and quantity of production. There is then a link through orchard gate returns and cash orchard surplus to consumers when they purchase the fruit. (This link would include many other actors such as shippers and other intermediaries). The price signal goes back to the orchardists but the fruit is consumed by the buyer. Consumers, through their requirements, influence ZESPRI. The circuit is completed by the link from ZESPRI to decision maker.

Essentially, there are five important factors included in the above circuits which feed back to orchardists and affect their management. These are: (1) quality and quantity of production, (2) orchard gate returns, (3) cash orchard surplus, (4) ZESPRI and (5) contractors and packhouse. Only three factors of production (fertiliser and soil fertility, weed and pest management and contractors/packhouses) show as feedbacks to the decision maker at this level of the map (i.e., for scores above four).

Other important links are those to satisfaction. In effect, this goal is very relevant to the orchardist as decision maker since, after all, it is the decision maker who experiences the satisfaction. There are two main sources of satisfaction, quality and quantity of production and orchard gate returns.

It is noteworthy that only fertiliser and soil fertility, and weed and pest management, are factors of production linked to quality and quantity of production. On balance, labour is not seen as an important factor but is seen as a production expenditure. This result may be due to the fact that for some orchardists the labour component is managed by the pack house or the contractor. However, neither is this factor strongly connected to quality and quantity of production. Similarly, plant and machinery, while clearly an important factor relating to production, is not seen as a vital part of the production system. Again, this may be due to the fact that machinery is provided by contractors and pack houses or perhaps due to kiwifruit production not requiring a lot of machinery. Overall then, fertiliser and soil fertility, and weed and pest management, are the two main ways orchardists affect quality and quantity of production, aside from the direct link from decision maker.

The causal map shows that orchardists see their system as one oriented to production. Most of the factors that can be characterised as mainly social were not included as an important factor in the group map. However, the interviews showed that in some cases there was pride in producing good fruit for its own sake so that there was satisfaction from production over and above the cash orchard surplus derived from production. We cannot tell if some of this apparently non-productive satisfaction was in fact linked to the expectation of higher returns from good quality fruit.

⁴ We acknowledge the contribution of Ika Darnhofer, University of Natural Resources and Applied Life Science, Vienna, to this part of our analysis.

The group map also shows important factors in the system over which orchardists have little control because they are, on average, transmitter factors. The data show that the orchardists have no influence on these factors (the link from the decision maker to each of them was zero). These factors include: weather and climate, regulations, soil type and topography, advisors/consultants and information. Of these factors, some have a braking effect (that is, they inhibit or adversely affect the orchard system) and these include weather/climate, regulations and soil type and topography. Weather/climate in particular is seen as very important since it not only influences the decision maker but has a direct effect on quality and quantity of production. While having no direct influence on these factors, it is wrong to see orchardists as passive in their response. Many of them take actions to manage their orchard to mitigate the effects of these factors. For example, they can and do install irrigation systems, construct wind protection, and fertilise their soils.

ZESPRI, and advisors and consultants, were two factors with additional influence on the decision maker but probably not as a braking effect. Data show a limited influence from decision maker to these factors (score of one). Finally, the map shows that there were two factors influenced by the decision maker but not otherwise connected strongly in the map. These factors were orchard environment health and time in farm work.

The group map data presented above show clearly the basic patterns of connection between variables connected at a level of four or more. However, the group map can also show connections that, while not consistently made across the 36 orchardists, were made by some orchardists so that the average score is less than four. These data reflect that some orchardists had maps with strong connections between factors not identified in Figure 2. Figure 3 shows the group map with scores of three. It indicates that some additional factors are connected at this level, many of them not involving the decision maker. Some of the factors are off-farm, such as neighbours, off-farm work, off-farm activities and government policies. The two goals of improving equity and retirement are included at this level. Figure 4 shows the group map with scores of two. Most of these connections go to the decision maker. Orchard environment health is seen as influencing quality and quantity, orchard as a place to live and the decision maker.

Figure 4: Kiwifruit group map with scores of three

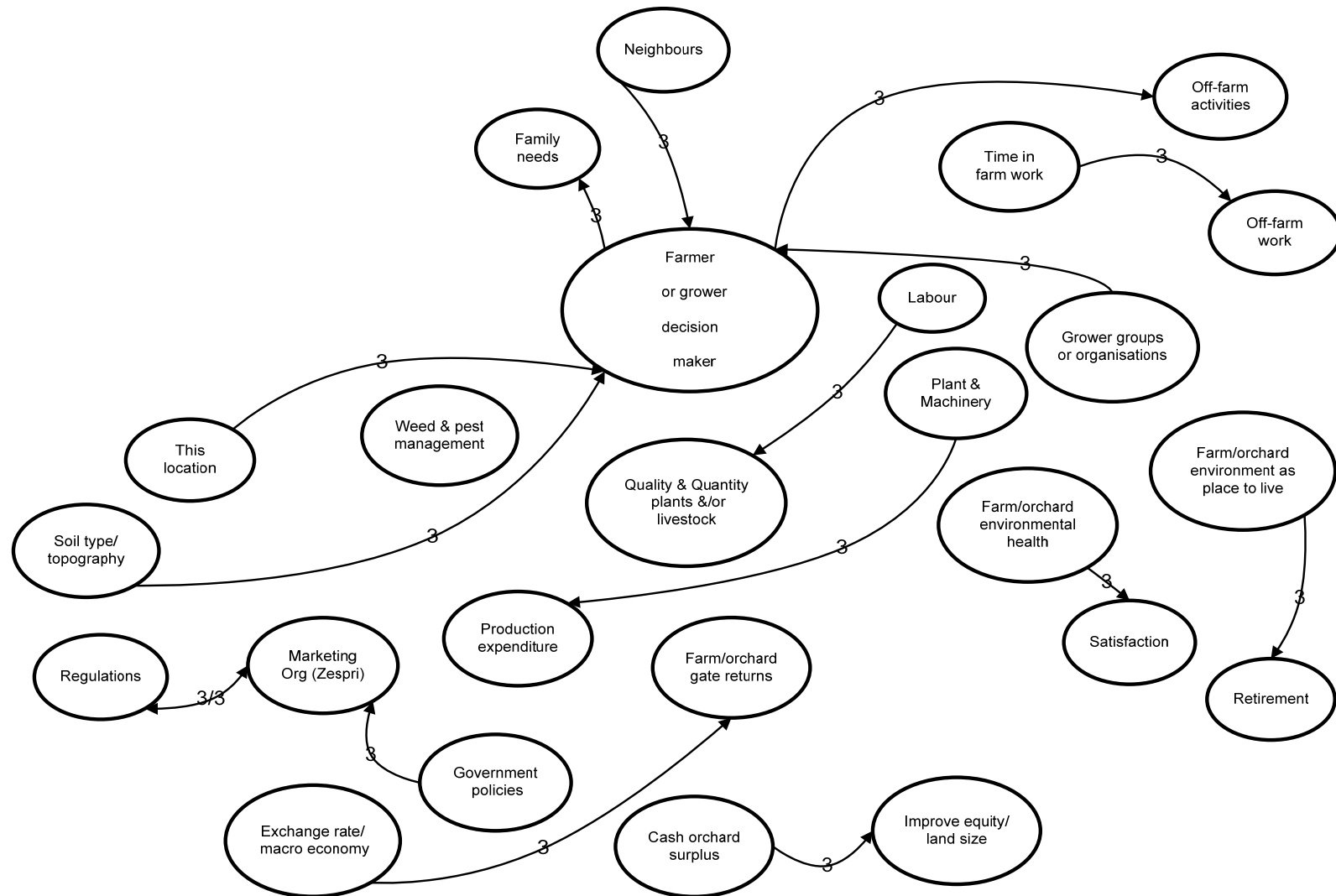
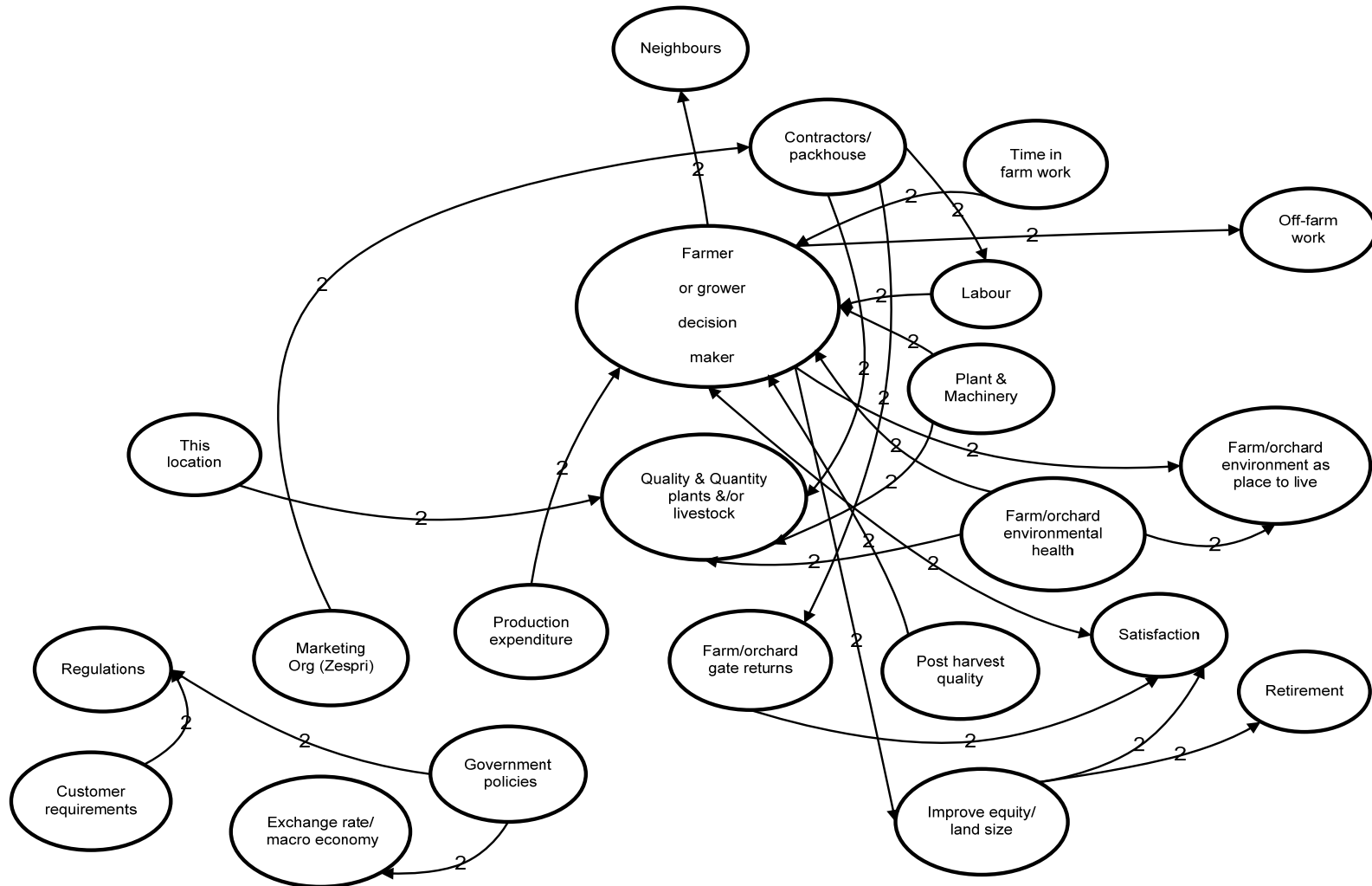


Figure 5: Kiwifruit group map with scores of two



3.3 Causal map inferences

A causal map can be simulated to determine its system properties. The simulation is performed by assigning an initial value (usually unity) to each of the factors and propagating those values through the weighted connections between the factors. The value of each factor is then re-calculated based on the weighted sum of the values of other factors connected to it, which is further transformed using a non-linear function. These updated values are then again propagated through the connections, this process being repeated until the values of the factors reach a stable state, that is, they no longer change from one batch of updates to the next.

Given an existing causal map, four types of analysis can be performed:

1. Finding the stable (or equilibrium) state of the system. Here the initial values for each of the factors are set to unity and the system is left to run until a stable state.
2. Setting the connection weights from each factor to zero to assess the role or importance of that factor in the system. If a factor's outgoing connection weights are set to zero and there is a major change in the final stable state of the system, then that factor is important to the system.
3. Setting the connection weights from each factor to a maximum value to assess the influence of that factor over the entire system. If a factor's outgoing connection weights are maximised, and there is a major change in the final stable state of the system, then that factor is influential.
4. Removing, or assigning high weights to, single connections to see if these disturb the final state of the system. This allows us to determine the resilience of the system to changes in relationships between factors.

From inspection of the causal map it was determined that the eight most significant factors in the map were marketing organisation (ZESPRI), decision maker, quality and quantity of production, production expenditure, orchard gate returns, cash orchard surplus, contractors and packhouse, and satisfaction. The final stable values of these factors at the end of a simulation, and the effect of altering the connections from these factors, were therefore of the greatest interest during the simulations performed.

The first analysis, as described above, was performed to establish a 'baseline' activation pattern for the causal map, that is, to establish the final stable activation values for each of the eight significant factors before any modification was made to the connection weights. These values are presented in the following plots of activation as points of comparison.

The second analysis was performed by systematically setting the outgoing connection weights for each of the eight most significant factors to zero. The outgoing connection weights were altered for one factor at a time. This had the effect of removing the influence of that factor from the causal map. The map was then run until a stable state was reached and the final values of the eight significant factors found. By examining the differences between the initial baseline, values and the values resulting from removing the influence of individual factors, the importance of the removed factor could be judged.

The third analysis was performed by systematically setting the outgoing connections weights for each of the eight factors to a maximum value of 8.1, this being the largest connection weight value in the unmodified map. By examining the differences between the baseline stable values and the stable values of the modified map the influence of that factor on the entire map could be judged.

The final analysis concerned evaluating the robustness of the map to changes in individual connection weights. To achieve this, each of the non-zero connections in the map was systematically set to the maximum value of 8.1, and the map allowed to run until it reached a stable state. The mean and standard deviations of the changes in value of the factors gives an indication of the robustness of the map. This process was then repeated, except where the weights were set to zero, effectively removing them from the map.

The results for all of the above described analyses are presented in Figure 6 through Figure 21. In all of the figures, the x-axis of the plots are the individual, significant factors. The labels used for these factors (variables) are abbreviated. These abbreviations, and the full name of the factors, are presented in Table 6.

Table 6: Abbreviations used in results plots

Abbreviation	Variable Name
Mar	Marketing organisation (ZESPRI)
DM	Decision maker
Qual	Quality and quantity of production
PE	Production expenditure
OGR	Orchard gate returns
OS	Cash orchard surplus
Con	Contractors and packhouse
Sat	Satisfaction

Results for the equilibrium state of the system

The equilibrium points for each factor are shown in Figure 6 as the unaltered positions, indicated by crosses. These results give some further insight into the causal map because these positions are not a simple reflection of the centrality scores. Decision maker, quality and quantity of production, orchard gate returns, production expenditure and satisfaction all have high final activation states. An unusual result is that satisfaction has a high final activation state when it has the lowest centrality score. In contrast, marketing organisation (ZESPRI) has a high centrality score but low final activation state. Similarly, contractors and packhouse has a modest centrality score but low final activation state. These last two factors are not so closely integrated into the system and over time the run to the equilibrium state suggests that they can become less important in the system. These two factors are characterised by being outside of the orchard while the other six are on orchard. This finding suggests that each external organisation needs to work at maintaining a durable presence in the kiwifruit orchard system.

Results of Zeroing Connection Weights

Plots showing the final stable activations of each of the eight factors of interest, before and after removal of certain factors, are presented in Figure 6 through to Figure 14. It can be seen from these plots that the removal of the decision maker factor from the map (Figure 7) caused the largest disruption to the map as a whole, while the removal of satisfaction (Figure 14) caused the least disruption. Changes were apparent to orchard gate returns, contractors and packhouse, cash orchard surplus and satisfaction, depending upon which factors were removed. Conversely, decision maker and marketing organisation (ZESPRI) were hardly altered at all, no matter which factor was removed from the map. These results confirm the importance of the decision maker.

Figure 6: Results of zeroing outgoing weights for Contractors

Stable Activations Before and After Zeroing of Weights for Contractors

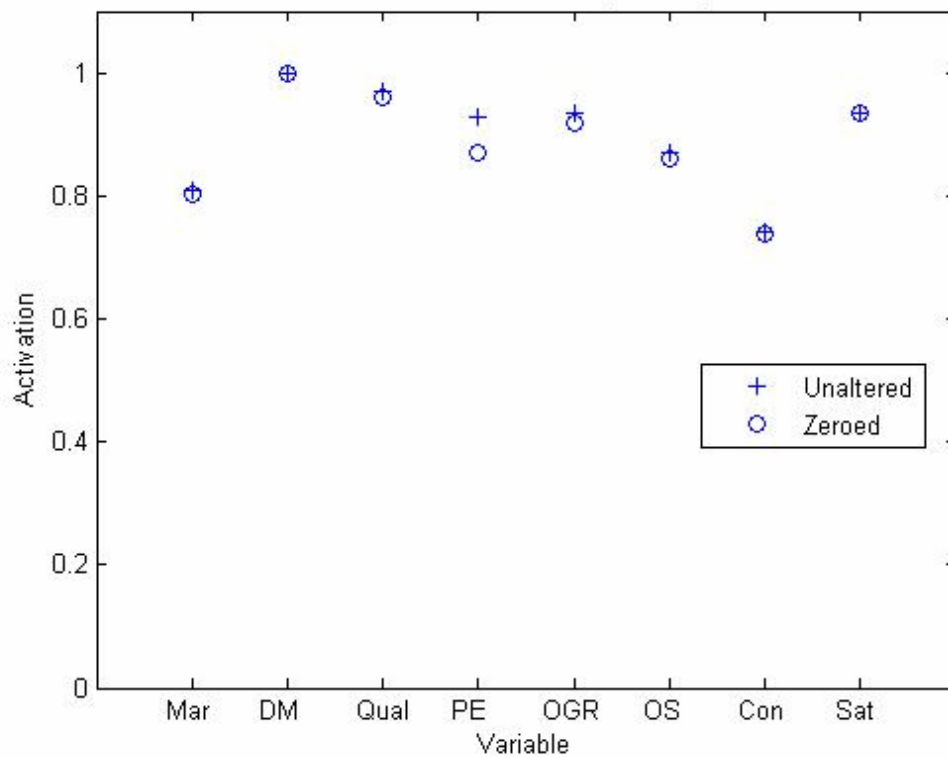


Figure 7: Results of zeroing outgoing weights for decision maker

Stable Activations Before and After Zeroing of Weights for Decision Making

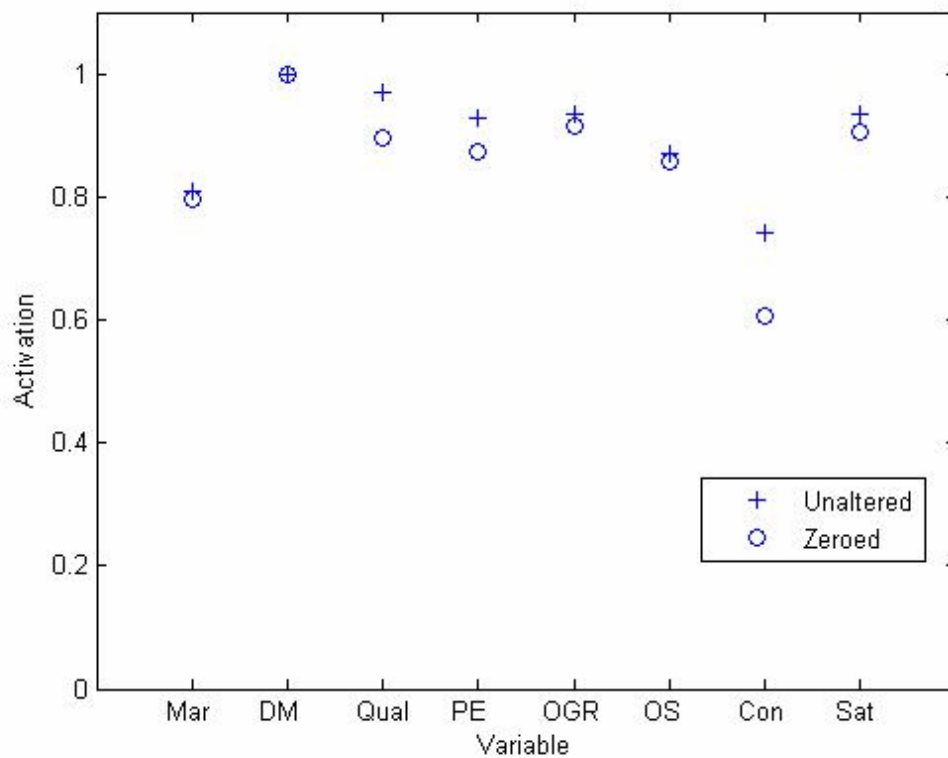


Figure 8: Results of zeroing outgoing weights for marketing organisation (ZESPRI)

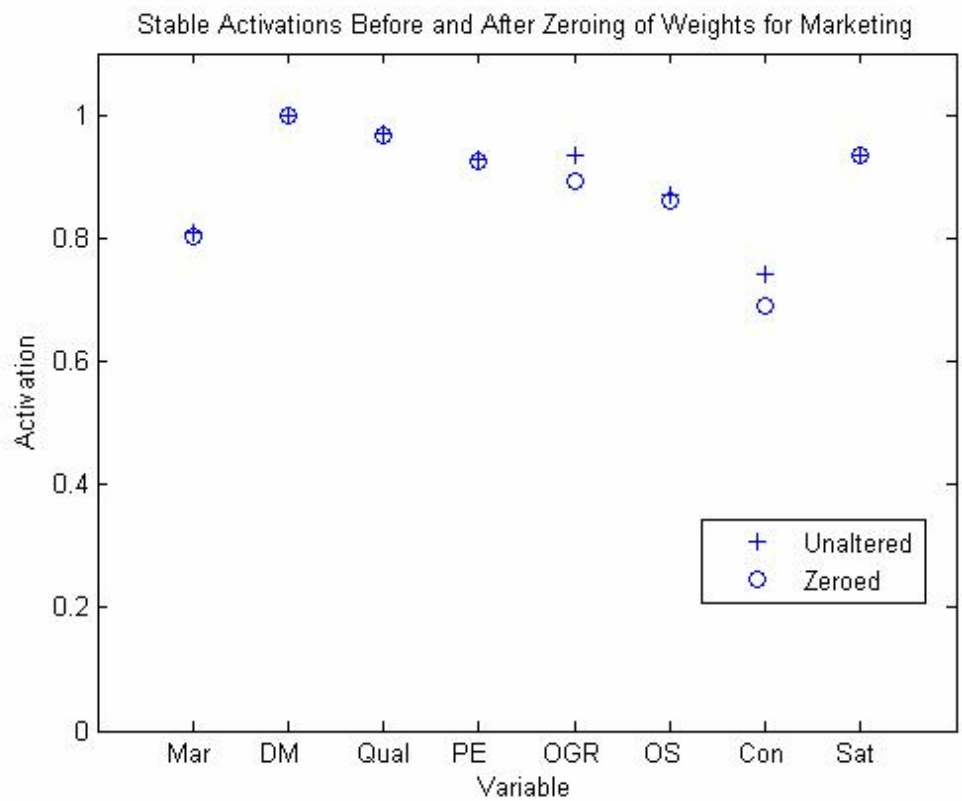


Figure 9: Results of zeroing outgoing weights for orchard gate returns

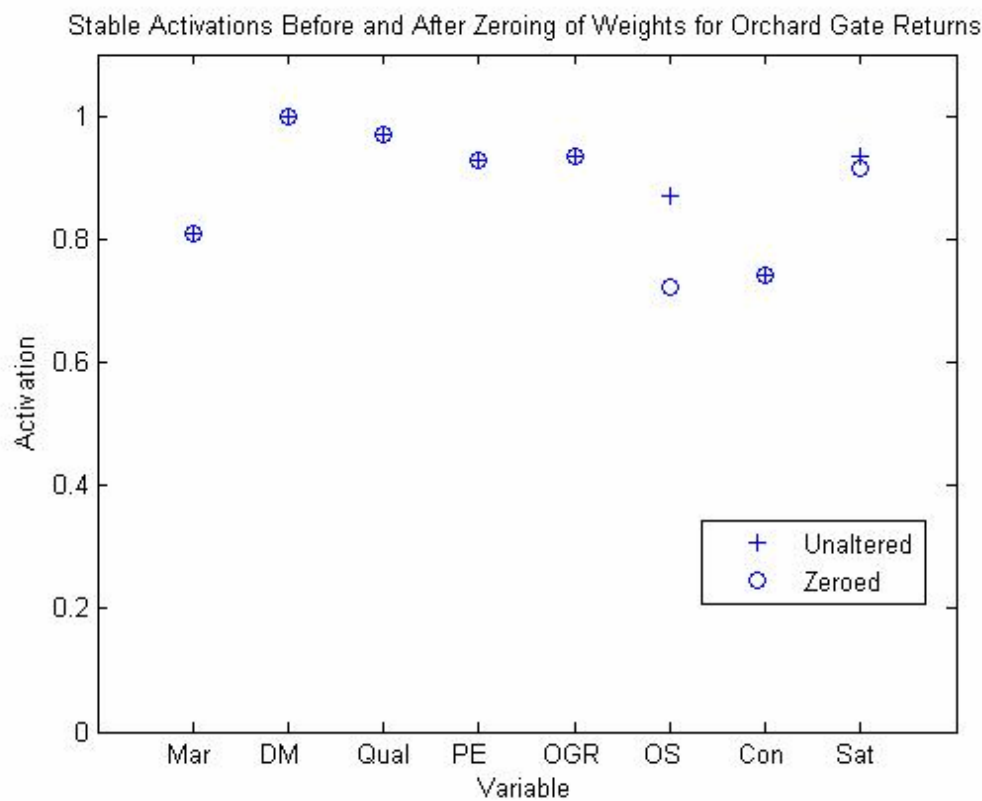


Figure 10: Results of zeroing outgoing weights for cash orchard surplus

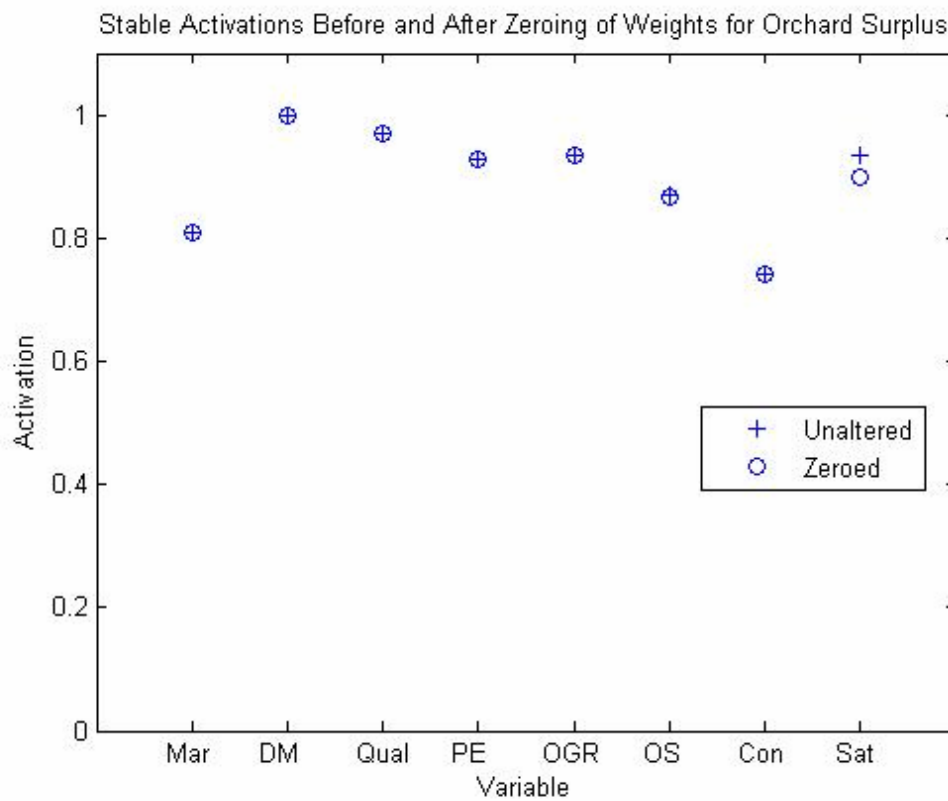


Figure 11: Results of zeroing outgoing weights for production expenditure

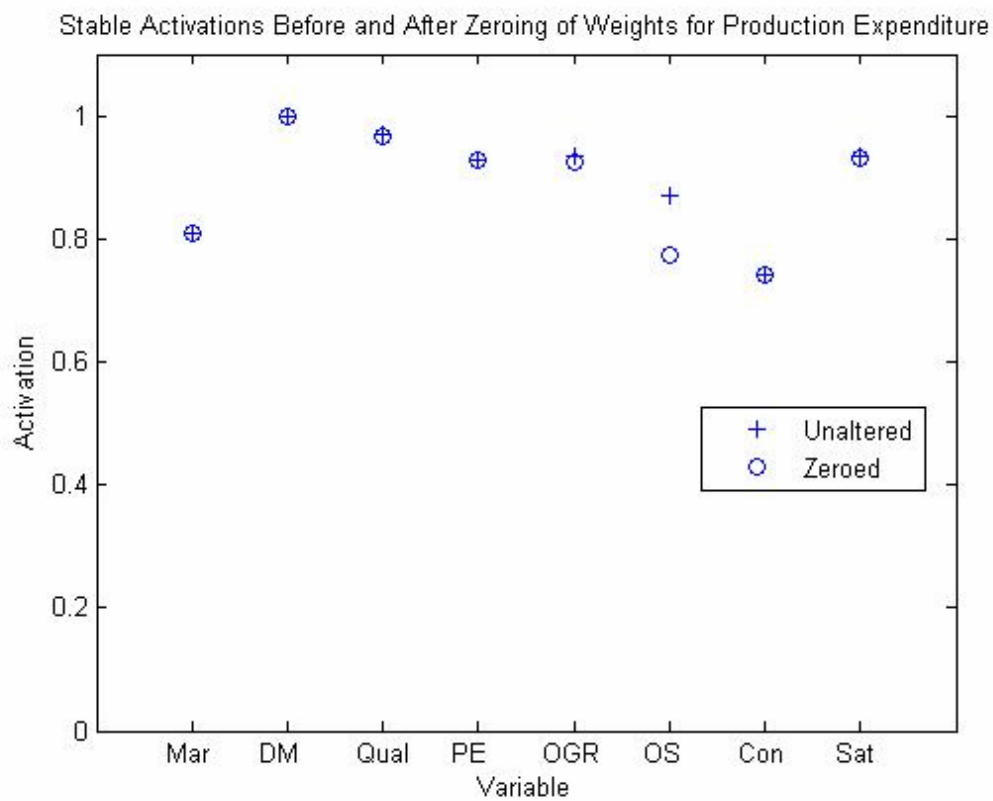


Figure 12: Results of zeroing outgoing weights for Quality and Quantity of Orchard Produce

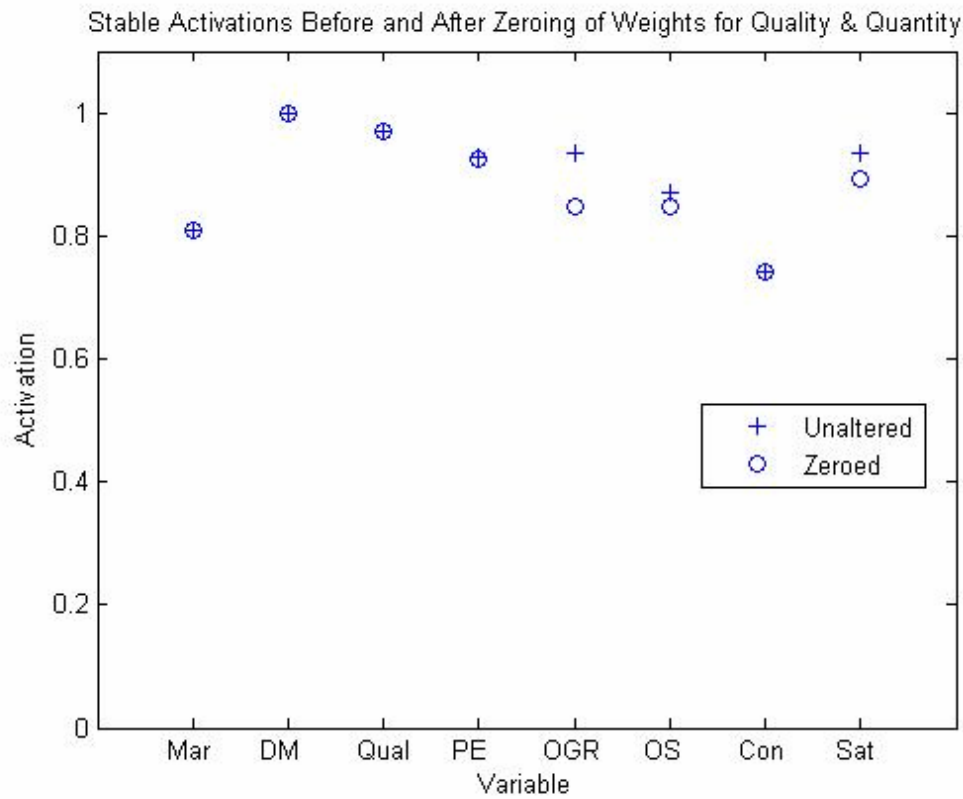
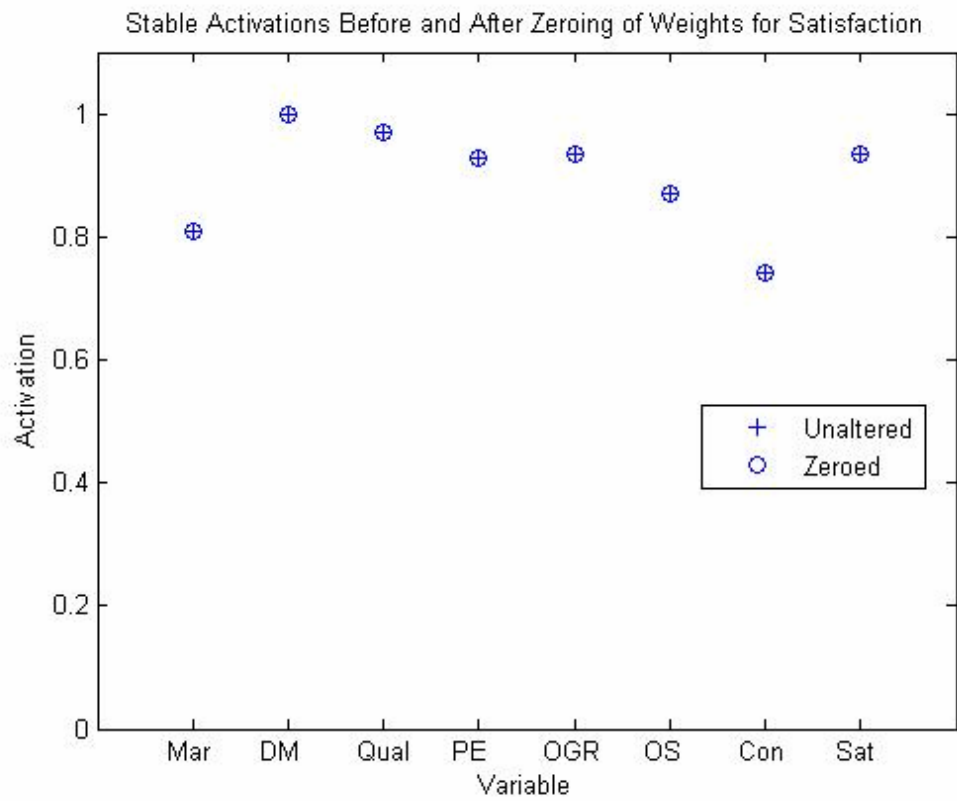


Figure 13: Results of zeroing outgoing weights for satisfaction



Results of Maximising Connection Weights

Plots showing the final stable activations of each of the eight variables of interest, before and after removal of certain factors, are presented in Figure 14 through Figure 21. While removing factors from the map caused the activation of the remaining factors to decrease, as expected, maximising their outgoing connections caused the activations of most factors to increase. Note that because decision maker was already at an activation level of unity, it does not show any change in activation in these plots. From the previous plots it can be seen that the activation of decision maker was not altered by removing any factors either, which indicates that decision maker is quite robust to perturbation.

Other than decision maker, the factor that was disturbed the least by maximisation of outgoing weights was quality and quantity of production, while contractors and marketing organisation (ZESPRI) were affected the most.

Maximising the influence of satisfaction created the greatest perturbation overall. Overall, these results show that the causal map is more sensitive to increases in contribution of any one factor than it is to the elimination of any one factor.

Figure 14: Results of maximising outgoing weights for Contractors variable

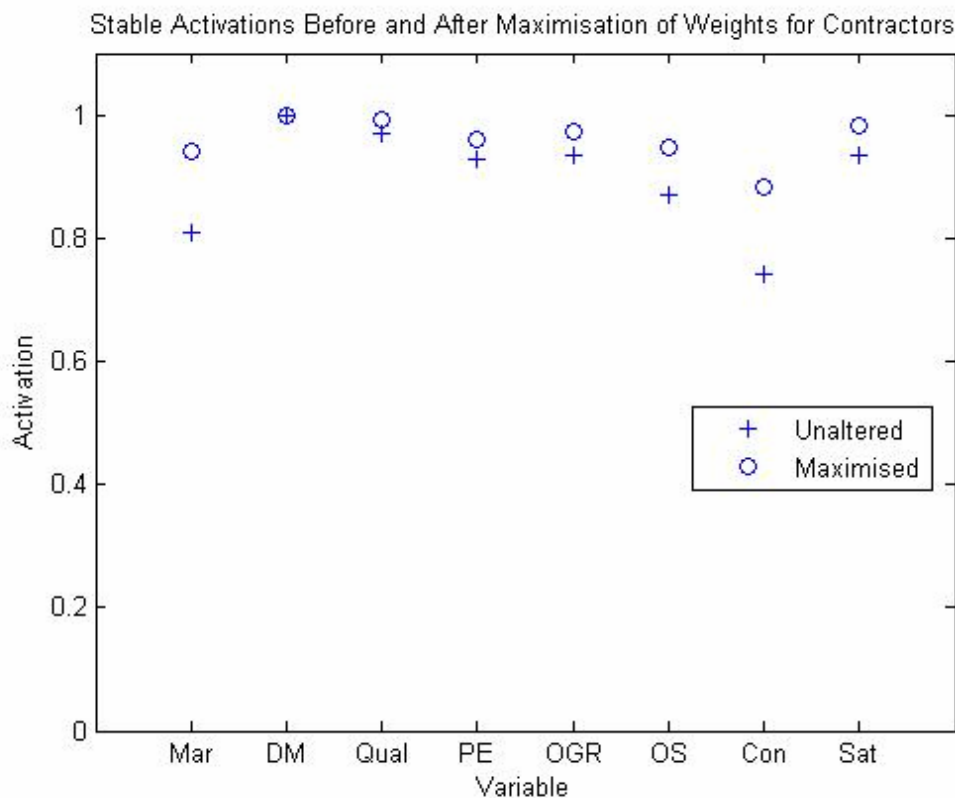


Figure 15: Results of maximising outgoing weights for decision maker

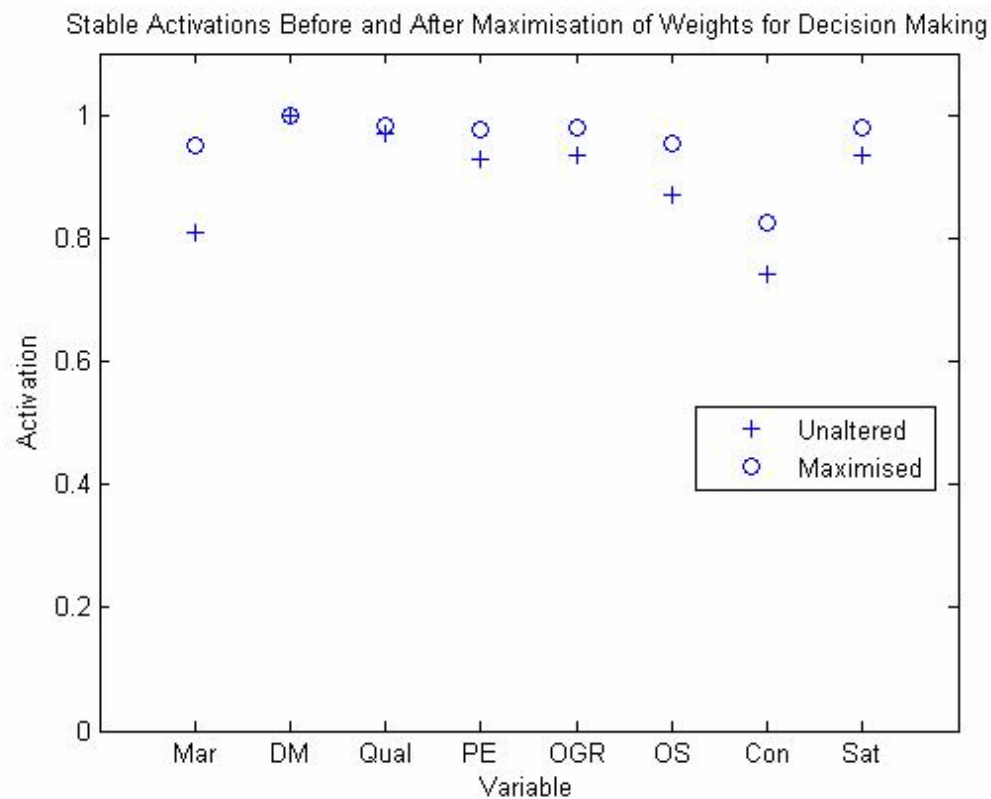


Figure 16: Results of maximising outgoing weights for marketing organisation (ZESPRI)

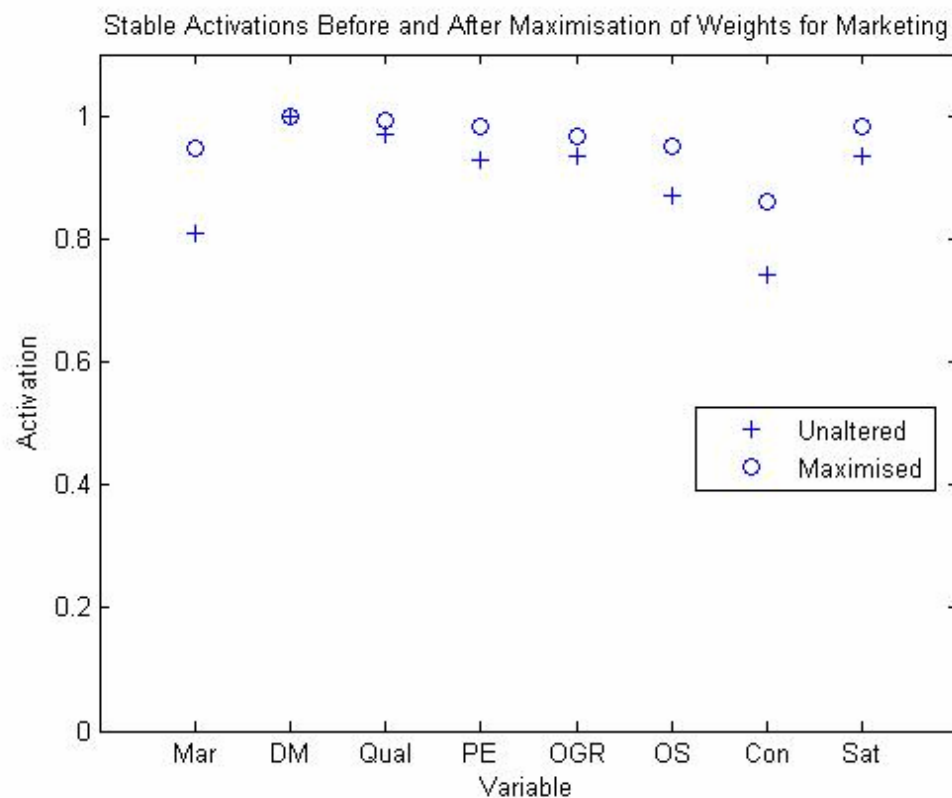


Figure 17: Results of maximising outgoing weights for orchard gate returns

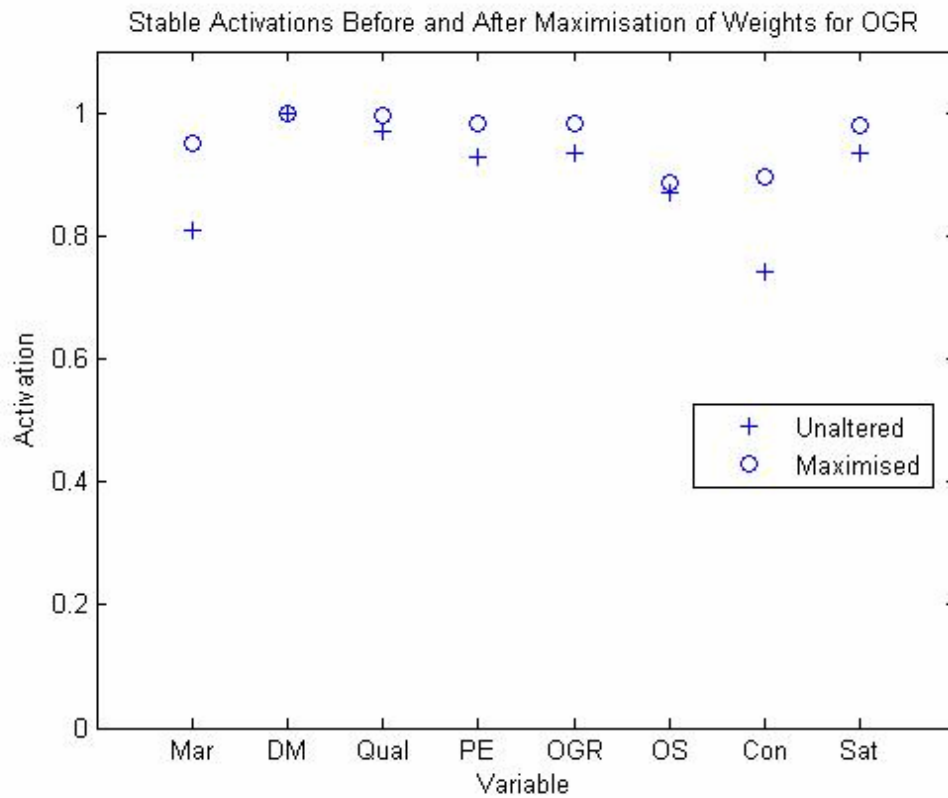


Figure 18: Results of maximising outgoing weights for production expenditure

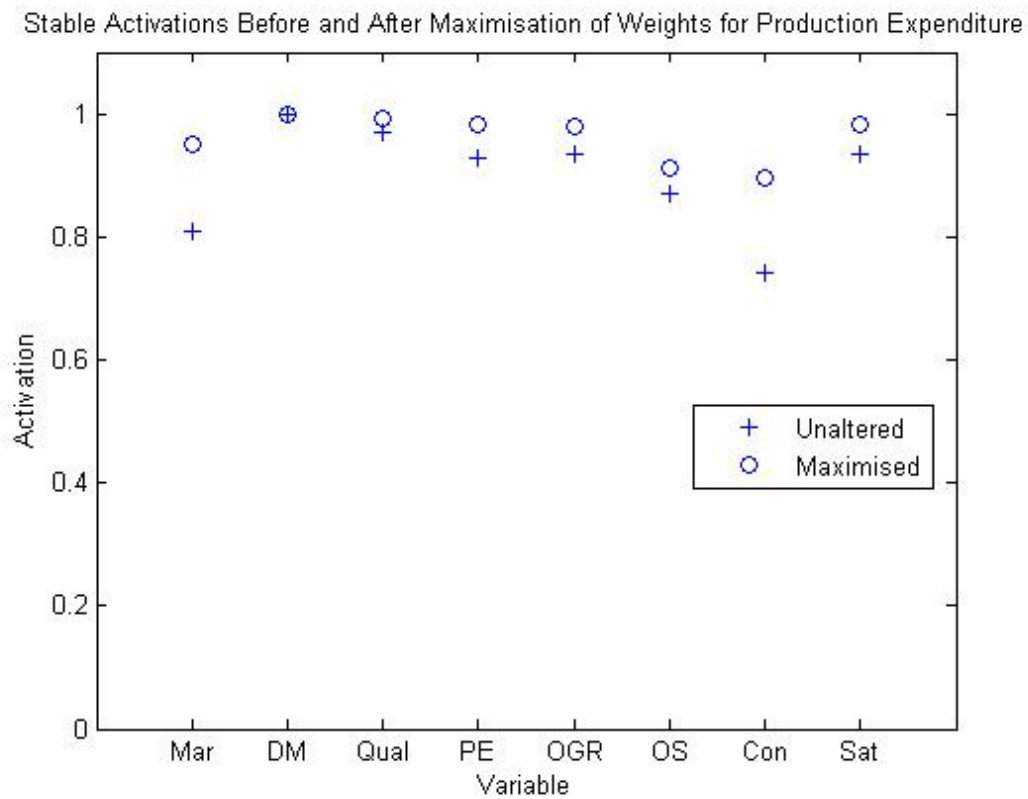


Figure 19: Results of maximising outgoing weights for Quality and Quantity of Produce

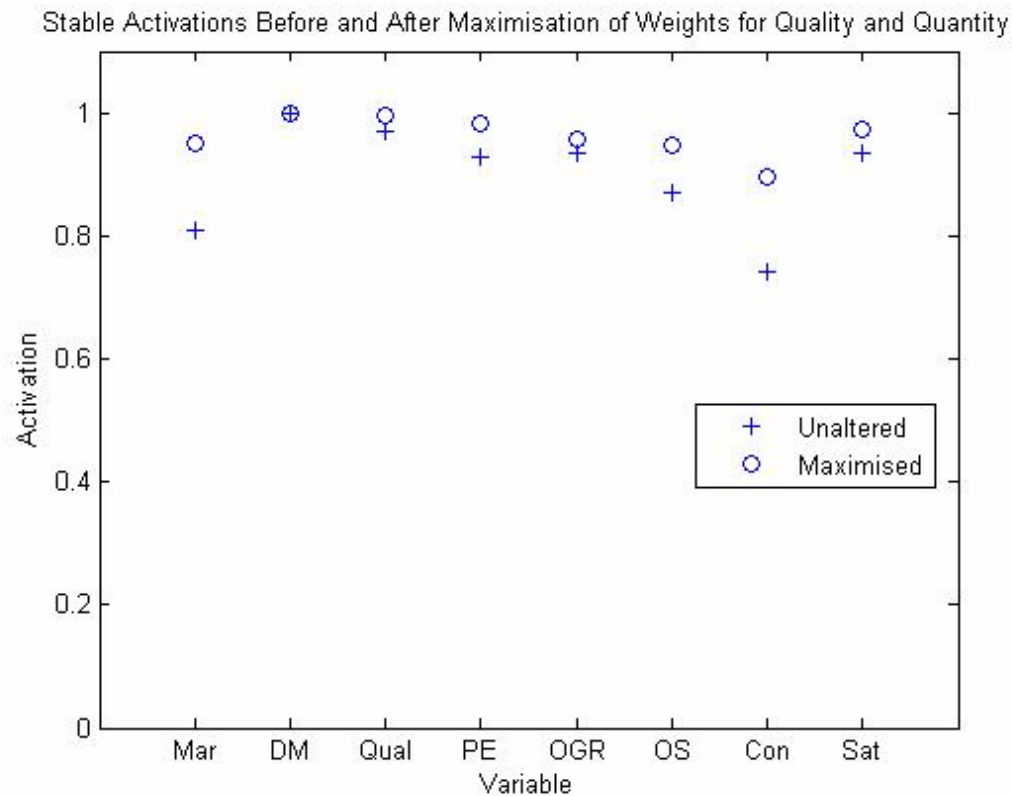


Figure 20: Results of maximising outgoing weights for satisfaction

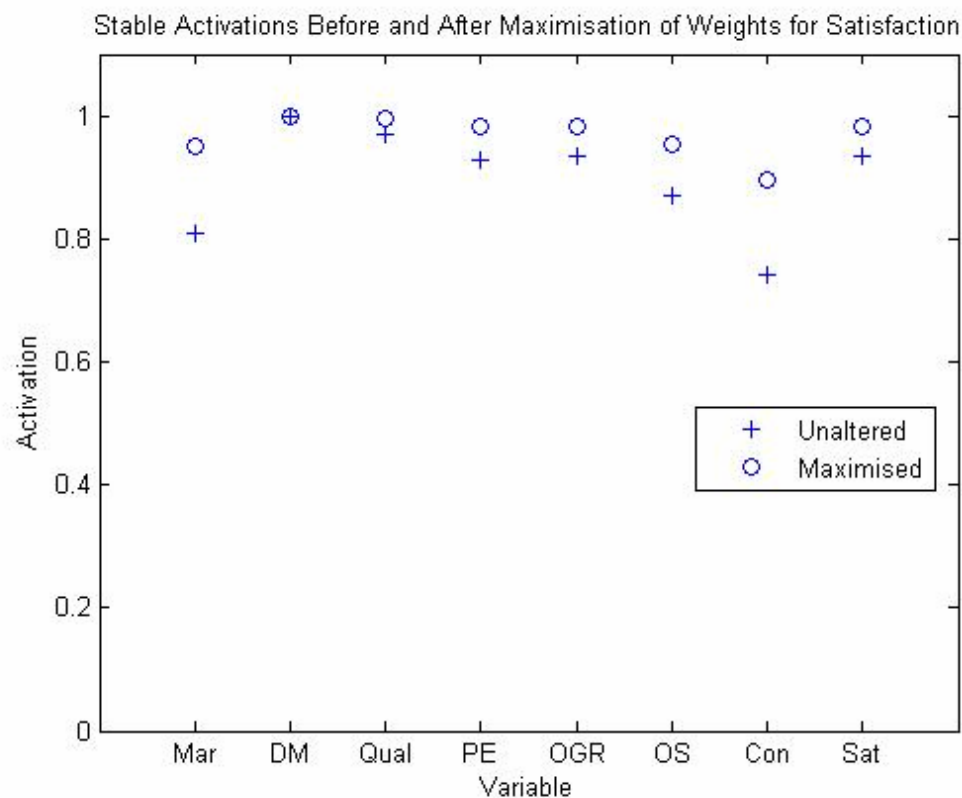
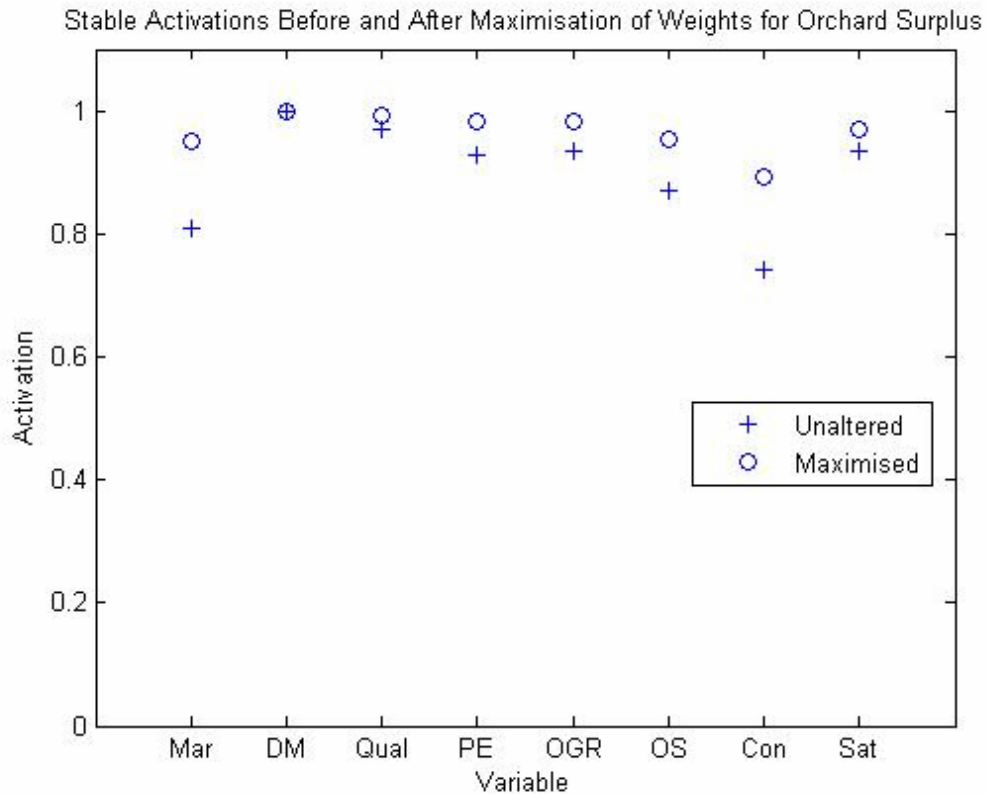


Figure 21: Results of maximising outgoing weights for cash orchard surplus



Results of Altering Individual Connection Weights

To investigate the effect of orchard environmental health on orchard gate returns, the weight of the connection between the two was set to the maximum value of 8.1. The results of this are shown in Figure 22, where it can be seen that this change did cause a small increase in the activation of orchard gate returns. None of the other variables were visibly disturbed, however.

To investigate the overall sensitivity of the map to changes in individual connection weights, two experiments were carried out. Firstly, each of the non-zero weights in the map was individually set to zero and the system run to a stable state. The results of this are plotted in Figure 23 where the mean and standard deviation of the change in activation of each of the factors is presented. Secondly, each of these weights was set to 8.1 and the system re-evaluated. The results of this, again in the form of the mean and standard deviation of changes in activation, are plotted in Figure 24. From these two plots it can be seen that the system was less disturbed by zeroing (effectively removing) connections than it was by maximising connections. What is quite interesting is the amount of variation in changes experienced by marketing organisation (ZESPRI) and cash orchard surplus. This indicates that there are some individual factors that have strong influence over the activation of these two factors.

Figure 22: Activations for a connection weight of 8.1 from orchard environmental health to orchard gate returns.

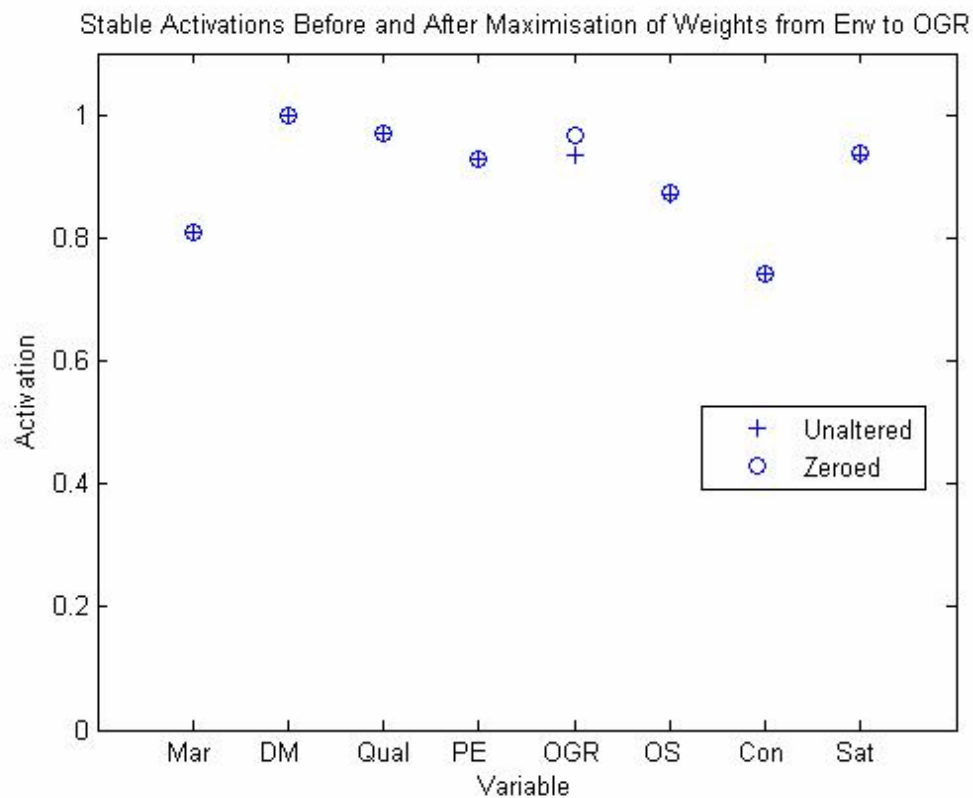


Figure 23: Results of removing individual weights

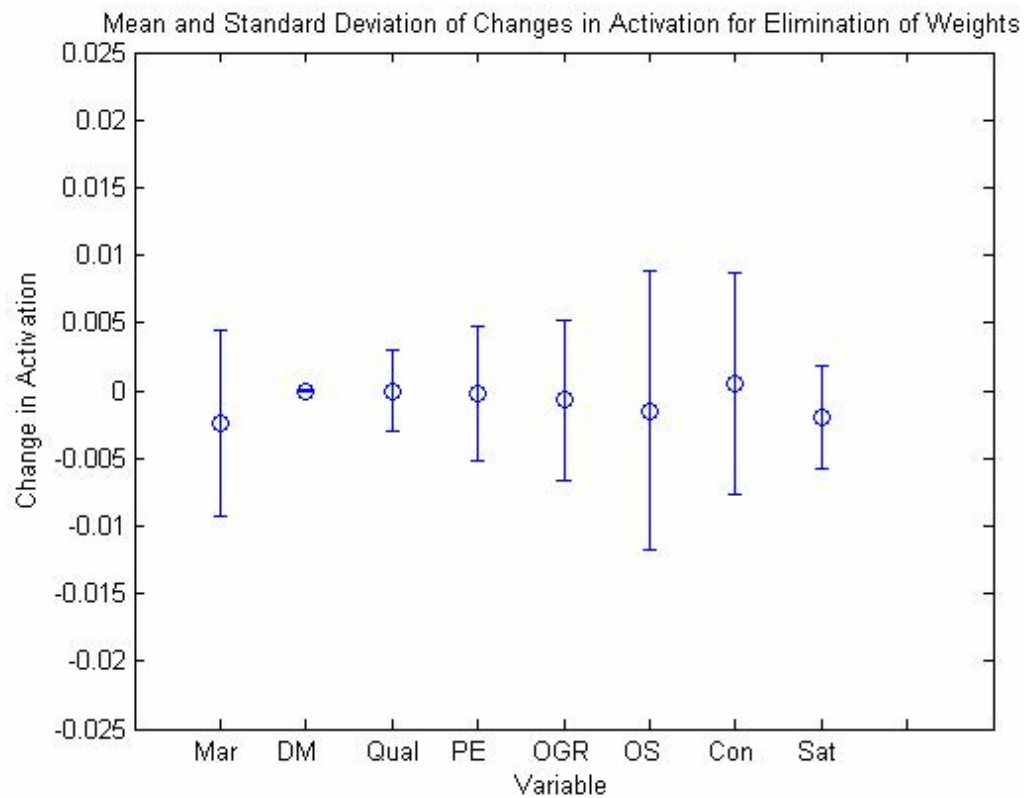
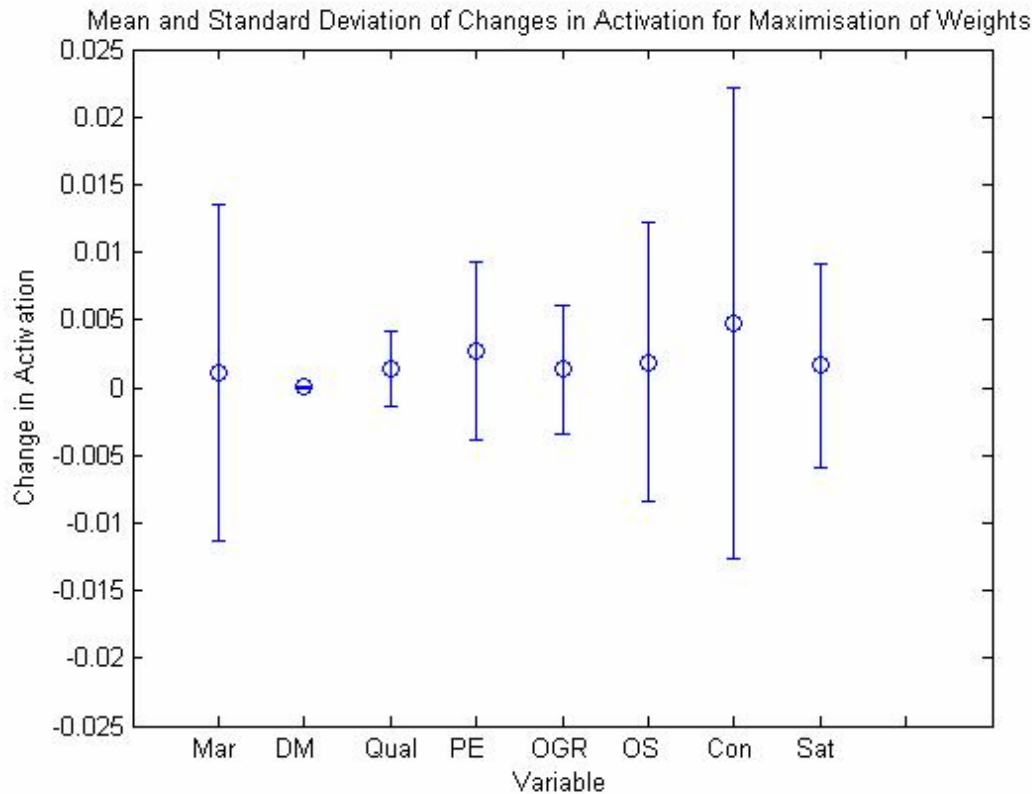


Figure 24: Results of maximising individual weights



Discussion

Overall, these simulation results show that the causal map system is stable and not easily changed, although maximising connection weights causes greater changes to the system than eliminating them. This raises the question of what would it take to bring about a change? How many factors would need to be changed? What weights would need to be changed? One way to address these questions would be to run an evolutionary algorithm during the course of a simulation run in order to examine the effect of change in the structure of the map. This would then allow one to determine what is needed to bring about an effective policy change. A policy example would be to assess what would be needed to make orchard environment health more significant in the system. Possible links to introduce would be from decision making, fertiliser and soil fertility, weed and pest management, and from quality and quantity of production to orchard environment health.

The results to date suggest that significant change would only occur if a number of factors were changed. Since the decision maker is the most important factor any policy change must include it.

3.4 Group map data for each panel

The assessment of differences between the group maps created for each of the ARGOS management panels involved the identification of significant differences for centrality scores (using both means and frequencies) among the panels. To facilitate the analysis, the data from the individual maps were combined into one table that listed the 36 orchardists in groups for each panel, and collated the 36 factors in 36 columns of data. This table is shown in Appendix 3. These data were examined using ANOVA and the results are shown in Table 7. Bold font identifies statistically significant differences at the five per cent level of significance. In addition, an asterisk in the adjacent column indicates instances in which location contributed significantly to the variation. Similar analyses were conducted for the

indegree and outdegree values of each factor. The results of these additional analyses are used to help explain the differences occurring in Table 7 and are presented in two tables in Appendix 2.

The data in Table 7 show that there were five factors that had significantly different mean scores for centrality. Of these, both production expenditure and information differed between Gold and Green management systems. Production expenditure was more important to Gold orchardists than Green. (Examination of the indegree and outdegree results suggests that this result was driven by the indegree means which are also significantly different. In addition, the indegree and outdegree results show Green was also significantly different from Organic.) The importance of production expenditure to Gold indicates that production expenditure is impacted on more by other factors for Gold who appear to see their systems as more complex than do the Green participants. The differences in the means for the decision maker are not significantly different because the data have a high level of variance.

In order to understand which factors were seen to cause production expenditure, the data for the important factors connected to it for each panel are shown in Table 8. These data are not the same as the centrality data because they do not include all linkages to and from production expenditure, just those that cause it. Bold font is used to show a linkage with a weighting that exceeds by at least one the overall average weighting value which is four or above. While not necessarily statistically significant, the latter factors are important in explaining the statistical differences identified in Table 7. We give more emphasis to high loadings rather than very low loadings because these can fit into Figure 2 to show important connections for particular panels.

Table 7: Centrality means and frequencies for Gold, Green and Organic orchards

Factor	Means of values given to connections between factors				Frequencies of connections to other factors			
	Gold	Green	Organic	Loc'n	Gold	Green	Organic	Loc'n
The decision maker	168.1	148.8	186.4		25.3	20.8	28.6	
Quality and quantity of production	58.4	70.6	52.6		7.6	8.8	7.3	
Orchard Gate Return	41.7	38.1	41.9		4.7	4.9	5.5	
Marketing organisation (ZESPRI)	40.6	40.2	42.9		5.5	5.1	6.0	
Production expenditure	41.8	30.3	40.3		6.1	4.4	6.7	
Contractors & Packhouse	33.0	49.2^(a)	26.8	*	4.9	6.4	4.4	*
Cash Orchard Surplus	30.5	32.3	29.4	*	3.8	3.8	3.8	*
Satisfaction	30.1	28.3	31.1		4.0	3.5	4.5	
Fertiliser and soil fertility	24.3	22.8	26.2		3.5	3.1	3.7	
Weed and pest mgmt	21.6	23.0	22.3		3.7	3.3	3.6	
Labour	23.4	22.2	18.2		3.1	2.7	2.9	
Farm/orchard environmental health	16.1	17.4	27.0		2.8	2.3	3.9^(b)	
Post harvest quality	20.2	17.5	23.1		2.8	2.3	3.3	
Regulation	18.4	16.0	21.4		2.8	2.2	3.3	
Time in farm work	21.4	20.0	15.8		3.0	2.6	2.8	
Weather/climate	17.0	17.3	15.6		2.2	2.2	2.3	
Farm/orchard place to live	15.7	12.0	17.8	*	2.2	1.5	2.4	
Plant & machinery	11.3	14.4	14.8		2.1	2.3	2.6	
This location	16.8	10.5	12.0	*	2.2	1.5	1.9	
Advisors, consultants	14.8	17.2	7.9		2.6	2.5	1.8	
Soil type/topography	12.1	11.0	11.4		1.7	1.6	1.8	
Customer requirements	13.7	10.5	11.6		1.8	1.3	1.7	
Improve equity/land size	15.3	10.8	6.1		3.0	2.5	2.3	
Exchange rate, macro economy	11.8	12.2	10.3		1.4	1.5	1.5	
Family needs	13.5	7.8	11.8		1.8	1.3	1.8	
Government policies	8.0	9.2	14.1		1.3	1.3	2.5^(b)	
Information	13.1	6.9	9.9		1.8	1.0	1.8	
Off-farm activities	9.5	9.6	10.2	*	1.3	1.2	1.8	
Neighbours	7.4	7.8	4.8		1.7	1.2	1.7	
Grower groups or orgs	9.3	3.3	5.8		1.8	0.7	1.3	
Off-farm work	6.3	7.1	5.5		1.0	0.9	1.1	
Retirement	7.9	6.4	4.1		1.2	0.8	0.8	
Future generations	5.6	4.9	3.5		0.8	0.8	0.6	
Community	4.0	1.8	6.3		0.8	0.3	1.8	
Smallholding/subdivision	5.0	0.8	5.1	*	0.8	0.1	1.3	
Family history and b/ground	4.1	1.3	2.1		0.6	0.3	0.7	**

Notes: 1. Bolding indicates significant differences at a 5% level of significance.
2. a. Green significantly different from both Organic and Gold.
b. Organic significantly different from both Gold and Green.
3. Asterisks indicate where location made a significant contribution to the variation within the data. * indicates 5%, ** indicates 1 % significance.

Table 8: Weightings given to the factors affecting production expenditure for Gold, Green and Organic

	Gold	Green	Organic	Overall
Fertiliser and soil fertility	5.3	4.3	6.3	5.3
Weed and pest management	4.7	2.4	4.6	3.9
Plant and machinery	1.8	3.3	3.9	2.7
Labour	6.8	4.9	5.7	5.8
Contractors and packhouse	6.2	8.2	6.0	6.8
Sum	24.8	23.1	25.4	

The data in the table show that the sum of the weightings is lowest for Green as we would expect given the low centrality of this factor for Green. Fertiliser and soil fertility (6.3) was high for Organic. Contractors/packhouse costs (8.2) were high for Green. Labour (6.8) was high for Gold. The significance results above and these data warrant the addition of the bolded numbers to Figure 2. The different weightings by panel have been attached to the respective linkages to production expenditure in order to show the variations for the different production systems described here. The table also indicates that weed and pest management (2.4) is low for Green orchardists and plant and machinery (1.8) is low for Gold.

Returning to Table 7, the other factor for which Gold has a significantly higher mean centrality score was information. This was more important to Gold orchardists than Green; but the centrality in both cases was very low, indicating that the factor was not as important compared to others. However, the main link here was from information to the decision maker (Gold 7.5, Green 6.9, Organic 6.2) and these scores indicate that by itself this link is important. The high loading of 7.5 is included in Figure 2. Perhaps the newness of Gold means that there is a greater requirement for information on how to grow it.

Table 7 indicates that quality and quantity of production was more important to Green orchardists compared to Organic. This finding is supported by a similar significant difference in the indegree analysis. Table 9 shows the relevant weightings data and the high values given to weather/climate (6.9), labour (5.7) and contractors/packhouse (5.1). As above, these bolded numbers are presented in Figure 2.

Table 9: Weightings given to the factors affecting quality and quantity of production for Gold, Green and Organic

	Gold	Green	Organic	Overall
Weather/climate	4.5	6.9	5.7	5.7
This location	3.5	3.1	0.6	2.4
Soil type/topography	4.0	4.6	2.5	3.7
Fertiliser and soil fertility	5.2	5.1	5.4	5.2
Weed and pest management	3.7	4.8	4.4	4.3
The decision maker	6.3	7.3	7.4	7.0
Plant and machinery	0.8	3.3	1.1	1.7
Labour	2.7	5.7	1.4	3.3
Contractors and packhouse	0.8	5.1	0.8	2.2
Farm/orchard environment health	2.3	2.3	1.1	1.9
Sum	27.5	40.9	23.0	

Low scores can be seen for Organic for soil type and topography (2.5) and labour (1.4).

The importance of contractors/packhouse is reflected in the next significant difference shown in Table 7. Contractors/packhouse was more important to Green orchardists than to either Gold or Organic, a result largely derived from a connection of an average value of 5.1 between contractors/packhouses to quantity and quality of production as shown in Table 9. The importance of contractors/packhouse to Green orchardists was reflected also in the indegree and outdegree results, however in the former only Organic was significantly different to Green. In addition, the high centrality score for quality and quantity of production was derived from the link from the decision maker to contractors and packhouse (Gold 4.0, Green 5.5, Organic 4.8, Overall 4.8).

Finally, Table 7 shows that orchard environmental health was more important to Organic orchardists than Gold. There is a link of 6.5 from decision maker to orchard environmental health for Organic, as shown in Table 10. The high centrality was also derived from a link from orchard environmental health to satisfaction (Gold 2.7, Green 1.6, Organic 5.1). This is backed up by the outdegree analysis which shows the same result. The bolded number, and the score of five from orchard environmental health to satisfaction, are presented in Figure 2.

Table 10: Weightings given to the factors affecting orchard environment health for Gold, Green and Organic

	Gold	Green	Organic	Overall
Fertiliser and soil fertility	0.0	1.3	1.5	0.9
Weed and pest management	1.4	1.7	1.3	1.5
Decision maker	5.5	4.3	6.5	5.4
Quality and quantity of production	0.2	0.7	0.0	0.3
Contractors and packhouse	0.0	0.7	1.3	0.6
Sum	7.1	7.7	10.6	

While not based on statistically significant differences between the panels, assessments of the variation in data for causes of satisfaction across the panels are interesting. Table 11 shows the data for five factors.

Table 11: Weightings given to the factors affecting satisfaction for Gold, Green and Organic

	Gold	Green	Organic	Overall
Quality and quantity	5.7	5.3	1.9	4.3
Orchard gate returns	2.7	2.0	1.2	1.9
Cash orchard surplus	3.2	5.3	5.2	4.5
Orchard environmental health	2.7	1.6	5.1	3.1
Orchard as a place to live	2.3	2.3	5.4	3.3
Sum	13.9	14.5	17.6	

For Gold the highest weighted factor causing satisfaction was quality and quantity of production (5.7). For Green the highest weighted factors were quality and quantity of production (5.3) and cash orchard surplus (5.3). For Organic the highest weighted factors were cash orchard surplus (5.2), orchard environmental health (5.1) and orchard as a place to live (5.4). Noteworthy is the very low score from quality and quantity of production to satisfaction for Organic, and the high score from orchard environment health and from orchard as a place to live to satisfaction. These bolded numbers are included in Figure 2.

For the frequency data in Table 7 there are some additional findings of interest. First, contractors/packhouse was related to a greater range of factors by Green participants compared to Organic. (For the latter result this difference is explained by the outdegree

difference between Green and Organic.) Second, production expenditure and orchard environment health had more connections for Organic. These results are similar to those for the means data. The balance of the significant findings (decision maker, regulation, government policies, off-farm activities and community) show a number of additional factors all with more connections to other factors for Organic compared to Green, independent of the value given to these connections. Putting it another way, while they may not have been important in terms of high causal scores they were important in that they were included. They are indicating a different quality in the way factors were linked. However, in the frequency analysis only Organic shows up as having more indegree connections from other factors than Green. This shows that though it had more connections to other factors, a little less value was placed on them overall by Organic orchardists compared with Gold, though of course, Green still had the least number of connections and the least value placed on those connections.

The frequency data in Table 7 shows that the decision maker was more important for Organic than Green, and this is explained by the frequency outdegree analysis which shows that Organic has a higher number of connections from the decision maker to other factors than does Green or Gold. The interviews showed that the decision maker played a very important role in the organic system. The same may have been true for Gold. Table 12 shows the weightings for the key factors affecting the decision maker. Family needs, fertiliser and soil fertility, regulation, weed and pest management and orchard gate returns are all higher in the Organic panel. These findings relate to means not frequencies so they are not warranted by the significance findings for frequencies considered here. Additional significance tests were carried out using the ten percent level of significance and some differences were found. Organic weightings were significantly higher for regulation and for orchard gate returns, and these weightings are incorporated into Figure 2. Gold weights were higher for information and this location. The former finding has already been added to figure 2 and the latter is incorporated. Also notable in Table 12 are the low scores given by Green to fertiliser and soil fertility and to orchard gate returns.

Table 12: Indegree weightings to the decision maker for Gold, Green and Organic

	Gold	Green	Organic	Overall
Family needs	4.7	3.0	5.8	4.5
Information	7.5*	6.9	6.2*	6.9
Advisors and consultants	5.1	6.2	5.5	5.6
Fertiliser and soil fertility	4.1	2.3	4.9	3.8
Weather/climate	5.1	5.0	6.3	5.4
This location	4.4*	1.8	1.6*	2.6
Regulation	4.3**	6.1	7.3**	5.9
Weed and pest management	3.3	2.7	5.0	3.6
ZESPRI	6.7	6.0	7.7	6.8
Quality and quantity of production	6.1	3.6	5.8	5.2
Orchard gate returns	4.8	2.0*	5.0*	3.9
Cash orchard surplus	2.3	4.8	5.0	4.1
Contractors and packhouse	4.5	6.2	5.2	5.3
Overall total	100.7	79.3	103.1	94.4

Note: * indicates 10% significance and ** indicates 5% significance.

Returning to Table 7, production expenditure was more important in terms of centrality for Organic than for Green using these frequency data although the means data show that Gold production expenditure was linked at a higher level than for Green. The general indication across both means and frequencies is that production expenditure was related to other

factors less by Green than either of the other systems. In contrast, contractors/packhouse was more frequently mentioned by Green compared with Organic.

The table also shows that orchard environmental health was related to more factors by Organic than Green or Gold. The means data show that Organic gave greater value to these connections than Gold so the general indication is that Organic emphasise orchard environment health. Regulation was also more important to Organic compared to Green and this reflects the fact that all organic orchardists were BioGro registered, a process that exacts certain management requirements. This is backed up by the fact that these orchardists gave the highest score to the link from regulation to the decision maker (Gold 4.3, Green 6.1, Organic 7.3), and this emphasis on the number of indegree connections is backed up by the indegree analysis which also shows this difference between Organic and Green as significant for the means data (Appendix 2). Government policies were more important to Organic than Green or Gold because they saw that these policies affected ZESPRI and therefore, presumably, affected them. This result is backed up by these significance differences occurring only in the outdegree frequency analysis for government policies.

Table 7 also shows that off-farm activities and community were more frequently mentioned by organic orchardists. However, the frequencies were very low. Community was important to organic orchardists and this reflects how some of them expressed the view that their production affected people near to the orchard, by virtue of not causing any ill health, for example. They saw that what they were doing was supporting the local community. When the indegree and outdegree analysis is considered it shows that this difference occurs for both indegree and outdegree connections, indicating the community both affected other factors and was influenced by other factors. (Gold also shows up as significantly different to Organic for the number of indegree connections from other factors.)

Interestingly, the indegree and outdegree analysis shows some other significant differences which have been masked by the centrality data (see Appendix 2). Cash orchard surplus and improve equity/land size show significant differences between Gold and Organic in the indegree means analysis with Gold giving a greater value to their connections to other factors. The location of the orchard was seen by Gold as being more influenced by other factors compared to Green. Customer requirements were seen as having less influence on other factors (outdegree) by Green compared with Gold and Organic, but this difference only shows up as significant between Gold and Green in terms of the number of connections. Gold connected advisors and consultants to more factors (outdegree) than Green or Organic. This may reflect the lack of knowledge Gold orchardists have and so they have a need to rely on advisors to manage orchard factors. Grower Groups or organisations showed as having more impact on and more connections to other factors for Gold orchardists compared to Green perhaps for the same reason.

The outdegree data for the decision maker in Appendix 2 can tell us how much each type of orchardist perceives that they have control over their orchard system⁵. Presently, the means outdegree data for decision maker show no significant differences across panels. However, the data in Table 13, broken into different factors influenced by the decision maker, suggest some differences. Organic have a higher overall outdegree score, and have a high score for fertiliser and soil fertility (7.7), plant and machinery (5.8), orchard environment health (6.6, already documented), and time in farm work (7.6). These values are shown in Figure 2.

⁵ Ika Darnhofer suggested this line of analysis.

Table 13: Weightings given to the factors connected from decision maker for Gold, Green and Organic

	Gold	Green	Organic	Overall
Neighbours	1.3	3.1	2.0	2.1
Family needs	2.0	3.2	4.0	3.3
Fertiliser and soil fertility	6.2	5.8*	7.7*	6.5
Weed and pest management	5.6	5.7	6.8	6.0
Quality and quantity of production	6.3	7.3	7.4	7.0
Contractors and packhouse	4.0	5.5	4.8	4.8
Labour	4.8	4.9	5.8	5.1
Plant and machinery	3.3*	5.1	5.8*	4.7
Orchard environment health	5.5	4.3*	6.5*	5.4
Time in farm work	4.6*	6.3	7.6*	6.1
Off-farm activities	2.6	3.4	3.6	3.2
Overall Total	67.4*	69.4	83.3*	73.0

Note: * indicates 10% significance and ** indicates 5% significance.

It is important to note that the group map shows that orchardists did not have a strong link directly to all the important factors in their system, as indicated by means and frequency centrality scores. Factors such as cash orchard surplus, orchard gate returns, satisfaction and ZESPRI have no direct connections from decision making. Of course, they may have arrow going from decision maker to and intermediary factor before connecting to these

Table 7 also shows that location explained a significant amount of the variation in the data. These location findings were different when they were based on means compared to the frequencies. They show that location has an effect on some of the factors and generally the results are what one would expect. For two factors, contractors/packhouse and cash orchard surplus, the results were similar for both means and frequencies. The finding for contractors/packhouse suggests that there is a regional variation in how they operate and this is perceived by the orchardists. The location effect for cash orchard surplus suggests that there are regional differences in net returns to orcharding and this could be explained by climatic effects on crop yield. The two factors of farm/orchard as place to live and this location were significant for means and this finding may have reflected that orchardists were thinking about what the location beyond the orchard and neighbours had to offer. Clearly, there are differences in what amenities and other attractions are available locally. Similarly, off-farm activities were linked to location because the presence of nearby towns or cities offers a wide range of things to do compared to more remote locations. The location effect for smallholding (means) reflects that smallholding and subdivision was more of an issue in some locations. For example, the three orchards near Keri Keri are all located close to the town and all are currently grappling with land use change possibilities that might manifest in the near future. The effect of location on family history and background (frequencies) probably just means that in some clusters one or more orchards had generational connections compared with most clusters which had none.

The data were also examined to see if the differences between the outdegree and the indegree values could be attributed to the different farm management systems (see Table 14). This analysis is a refinement of that offered in Table 7. Table 14 shows five significant results, four of which are similar for means and frequencies, However, four of the five are new findings compared to Table 7 and the consistent finding is for production expenditure. Production expenditure was seen by Gold more than Green to be more impacted on by other factors, and both Gold and Organic placed more connections to this factor than did Green.

In other words, Gold and Organic saw this factor as influenced by more factors than Green. These data support the results presented earlier. Returning now to the new findings in this table we consider customer requirements. The difference between the outdegree and the indegree values of customer requirements was due mainly to both the lesser value and the fewer connections this factor had with others by Green, reinforcing the results discussed earlier. The transmitting power of grower groups or organisations was due mainly to the emphasis placed on this factor by Gold, compared with both Green and Organic. This is probably because of the newness of the gold fruit makes membership of a grower group more important because of the information and knowledge able to be gleaned through this interaction. Organic participants saw smallholding or subdivision as having less impact than the Gold participants on their operation. Cash orchard surplus was impacted on more by other factors for Gold compared with green (and for Gold has become a receiver factor).

Table 14 also shows that location had a significant effect similar to that found in Table 7 where it was relevant for smallholding/subdivision and orchard as a place to live. However, a new finding was production expenditure as receiver was influenced by location. Presumably there are regional differences in costs of production that explain this result.

Finally, the causal map data were also examined for panel differences for the other variables used to characterise the maps. These other characteristics included the number of connections, the number of connections per factor, the complexity (the number of receivers divided by the number of transmitters), the density (the number of connections divided by the number of factors), the hierarchy index (an indication of the structure of the map in terms of whether it is hierarchical or democratic) and the number of double arrows. The results showed that only for the number of double arrows was there a statistically significant difference between the panels at the five per cent level of confidence. For Green the average was 4.3 compared to Organic at 8.5 and Gold at 8.3 showing that Organic and Gold orchardists had a greater sense of feedback loops between pairs of factors. For number of connections and number of connections per factor there was a significant difference at the ten per cent level of confidence. For Green the average number of connections was 51 compared to Organic at 59 and Gold at 59, and the average number of connections per factor was 1.6, 1.9 and 1.8 respectively.

Table 14: Differences between transmitters and receivers across panels

Factor	Out & indegree means difference				Out & indegree frequencies difference			
	Gold	Green	Organic	Loc	Gold	Green	Organic	Loc
Transmitters (high outdegree)								
Contractors & Packhouse	16.0	20.5	14.9		2.1	2.5	2.1	
Weather/climate	11.8	14.0	14.2		1.5	1.7	1.9	
Customer requirements	10.7	7.5	11.3		1.3	0.9	1.3⁽³⁾	
Soil type/topography	7.4	9.8	7.8		1.0	1.4	1.1	
Government policies	7.3	5.3	12.2		0.9	0.8	1.5	
Exchange rate, macro economy	8.6	8.0	6.7		1.1	1.0	0.8	
Labour	9.2	6.3	4.2					
Advisors, consultants	7.3	7.3	4.2		1.1	1.0	0.8	
Fertiliser and soil fertility	5.6	3.9	8.8		1.0	0.7	1.2	
This location	6.8	8.0	3.3		1.0	1.2	0.4	
Information	3.6	6.9	4.8		0.5	1.0	0.9	
Weed and pest management	4.9	1.3	7.1		1.2	0.5	1.3	
Regulation	3.8	8.0	1.6		0.7	1.0	0.1	
Grower groups or organisations	7.3	0.9	2.8⁽¹⁾		1.1	0.2	0.5⁽¹⁾	
Neighbours	3.3	1.7	0.4		0.5	0.2	0.2	
Family history and background	1.3	1.3	2.1		0.3	0.3	0.5	
Transmitters and receivers (ordinary factors)								
Plant & machinery	2.1	2.9	2.2		0.8	0.7	0.8	
Community	2.2	0.8	0.8		0.4	0.1	0.2	
Farm/orchard env. health	1.2	-1.4	3.8		0.3	-0.2	0.5	
Smallholding/subdivision	2.5	0.8	-0.1	*	0.4	0.1	-0.1	
Family needs	1.8	-1.1	0.8		0.1	-0.1	0.2	
Farm/orchard place to live	2.2	-2.0	-0.2	**	0.3	-0.3	0.1	*
Marketing org. (ZESPRI)	2.4	1.3	-4.4		0.3	0.1	-0.7	
Off-farm work	0.4	-2.3	-2.3		0.2	-0.3	-0.3	
Improve equity/land size	-1.3	-2.8	0.9		1.0	0.7	1.2	
Future generations	-0.9	-2.9	-2.0		-0.3	-0.3	-0.3	
Post harvest quality	-4.5	-1.2	-2.1		-0.8	-0.3	-0.3	
Cash Orchard Surplus	-9.5	-0.4	-3.1		-0.8	0.0	-0.1	
Receivers (high indegree)								
Time in farm work	-2.9	-3.0	-5.8		-0.3	-0.3	-0.8	
Off-farm activities	-2.5	-6.4	-2.7		-0.3	-0.8	-0.3	
Retirement	-7.9	-3.8	-4.1		-1.2	-0.5	-0.6	
Orchard gate return	-6.7	-11.9	-13.9		-1.7	-1.1	-1.8	
Quality and quantity of production	-12.4	-26.1	-9.1		-1.9	-3.6	-1.6	
Production expenditure	-23.2	-14.5	-20.7	**	-3.9	-2.5	-3.9⁽²⁾	
The decision maker	-33.2	-9.8	-19.8		-5.6	-1.9	-2.9	
Satisfaction	-24.6	-27.3	-24.8		-3.2	-3.3	-3.6	

Notes: 1. Green and Organic significantly different from Gold (5% level).

2. Gold and Organic significantly different from Green (5% level).

3. Gold and Green significantly different from Organic (5% level).

Chapter 4

Key Findings and Discussion

4.1 Introduction

This conclusion provides a summary of our research approach and of the results. It then interprets the result before discussing their implications. It concludes with a discussion of some limitations of the research and some implications for policy.

4.2 Summary of approach

This research had four objectives. The first was to document how orchardists participating in our ARGOS research describe and explain the management of their farm or orchard system. The second was to assess the results to test the ARGOS null hypotheses that there is no difference in the perceptions of management across the three different management systems under study (KiwiGreen Hort16A, KiwiGreen Hayward, and Organic Hayward). Meeting this objective also required consideration of the ways that the panels were similar. The third objective was to contribute towards some specific social objective aims, namely to identify sites of action for farmers, that is, places where action to achieve sustainability may occur, and constraints on that action. The fourth objective was to contribute to modelling the environmental system in which farmers operate. The four objectives have been addressed although most attention has been given to the first two objectives

Our review of literature showed that cognitive mapping has great potential to show how people see and understand a system that they are familiar with. While the method has had wide but modest use it has not often been used to study farmers. It has been used mainly in the resource management area, and occasionally in some other fields such as marketing and tourism. Cognitive mapping has been used in a variety of ways but only in some studies have participants been allowed to generate the maps. In the other cases, the researchers have used study results to build maps. Because of our social scientific approach and following some examples in the literature, we adopted the term 'causal mapping' for our application of cognitive mapping. We further argued that the work of Ozesmi and Ozesmi (2004) – as advocates of 'fuzzy cognitive mapping' – had promise as a mapping approach with which we could develop an understanding of farmers and their views about the systems that they manage. Accordingly, we followed the approach presented in Ozesmi and Ozesmi (2004), seeing that individual maps were unproblematic, but noted some concerns when individual map data are aggregated into group maps. On balance, we concluded that it was possible that the group maps could represent a perceived system, the main issue resting with claims about the validity of the maps. For example, the farmers' group map could contain an apparently inaccurate relationship between factors, one that independent scientific evidence did not support. Also highlighted in our assessment of FCM was its potential for application to a number of settings. While Ozesmi and Ozesmi (2004) note the possibility of applying a meta-analysis approach to mapping, this has not yet been reported in the literature.

Our application of causal mapping following Ozesmi and Ozesmi (2004) developed some different techniques as a result of careful pre-testing with a variety of farmers and orchardists. Instead of a completely unstructured approach, whereby each farmer developed his or her own list of factors relevant to their system, we found that the provision of the factors made for an easier mapping task, both in terms of recall and in terms of drawing. By using the results from our 14 pre-tests we were able to generate a comprehensive list of factors. Our approach settled on providing a map with 36 factors set inside circles and inviting each orchardist to connect up the factors to reflect his or her situation, with a clear request to add in additional factors if needed and to delete the ones not relevant to them. Upon completion of each map each orchardist answered some supplementary questions.

Accordingly, the scope and scale of the questioning process was moderated. Initially, the Ozesmi and Ozesmi (2004) approach of situating farmer activity in a wider ecosystem was addressed. Through further pre-testing, it became clear that farmers almost exclusively responded by describing their farming system, with little attention to wider ecosystem processes. Hence, the refined version of the instrument that was finally deployed concentrated much more specifically on farmer's management and decision making around their farm operation and the multiple causal influences on different aspects of the farm operation (including environmental influences).

The data were analysed by focusing mainly on the centrality of the factors, and their indegree and outdegree. After working with the data for all 36 farmers, attention was given to results within panels and identifying statistically significant differences.

4.3 Summary of findings

For the first research objective, the aim was to develop a full account of perception of a management system by identifying the factors that comprise the system and by showing how the factors were linked. This objective has been achieved with the development of the group map for kiwifruit orcharding. Maps were generated to produce quantitative scores on the qualitative perceptions of 'connectedness' of the elements of the orcharding system. The in-degree, out-degree and centrality scores summarised below indicate the basic 'connectedness' of the perceived system.

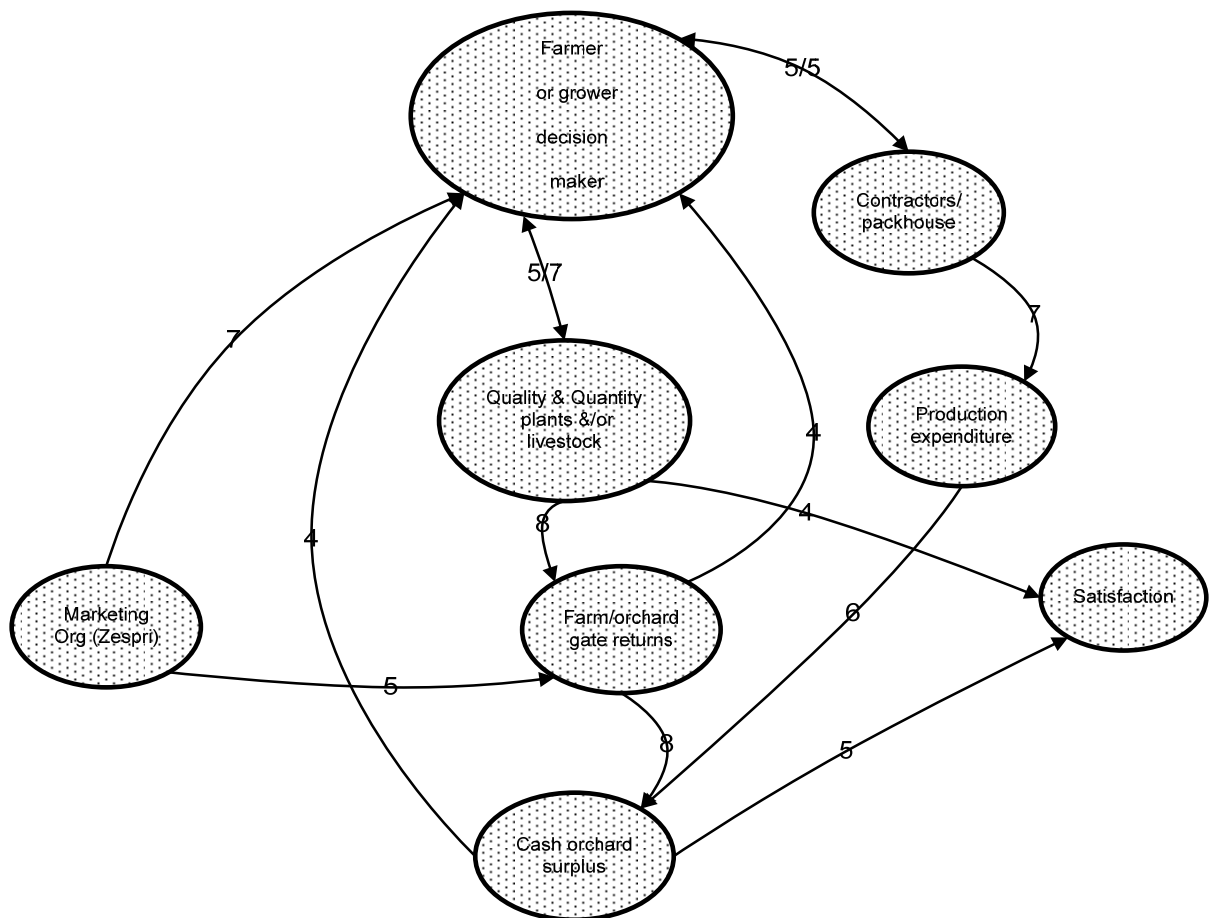
The first set of interesting results were those that were most notable by their absence. The pre-testing of the maps showed that the Ozesmi and Ozesmi (2004) focus on the broad ecosystem which stakeholders were relating to did not emerge spontaneously from qualitatively elicited responses from growers. Instead, the pre-test farmers compartmentalised (or even ignored) wider environmental processes as something that lay external to the farming system they managed. The system they generated was, in contrast, highly human-centric and eco-exclusionary. The maps that the full sample of orchardists produced showed a very production-centric view of farm management in all but a small minority of the orchardists. To be fair in our comparison to Ozesmi and Ozesmi (2002), they focused on ecosystems beyond the farm while our study focussed on the farm itself and our narrower focus may explain why our results were different in this respect. We will return to this issue of scale in the discussion.

Due to this early result from the pre-testing, the scale and scope of questions around the generic map were re-focussed to more carefully explore this highly production-centred vision of the orchard and its causal influences.

The results from the 36 individual causal maps show that on average 31 out of 36 factors were used by the orchardists. For the kiwifruit group map formed from all 36 individual maps the factors with high centrality show that at the heart of orcharding was the decision maker, strongly influenced by, and influencing, production, financial aspects (represented by returns, expenditure and orchard surplus), the two industry organisations with influence over the kiwifruit industry (ZESPRI and the contractors/packhouse), and satisfaction. These important factors, as indicated by high centrality, tend to have a high indegree value, meaning that they were seen to be influenced by other factors rather than as influencing other factors.

Overall, the key elements of the group map can be shown by reporting just those factors that received a high centrality score, as shown in Figure 6.

Figure 25: Key elements of the kiwifruit group map



This stark figure shows seven production related factors and satisfaction. Production is influenced by the decision maker and this plus ZESPRI influences orchard gate returns. Contractors/packhouse plays a key role having a bidirectional connection to decision maker and being the main cause of production expenditure thus influencing cash orchard surplus. The latter and quality and quantity of production influence satisfaction. Finally, ZESPRI has a very strong influence on the decision maker. Of all the causal connections, only those between the decision maker and quality and quantity of production, and between the decision maker and contractors/packhouse, are bidirectional. The strongest link is from production to orchard gate returns.

The same basic pattern in the group map was found for both means and frequencies of the causal connections. However, using a weighting based on the average score divided by the average frequency to produce a value per linkage shows a different pattern. The most important connections between factors were between orchard gate returns, cash orchard surplus, exchange rate, customer requirements, quality and quantity of production and weather/climate, while less emphasis was given to decision maker, production expenditure, and contractors and packhouse. This implies that when orchardists included the former factors they gave them a high score whereas when they included the latter factors they gave them a lower score. Note that orchard gate returns, cash orchard surplus, quality and quantity of production, decision maker, production expenditure and contractors/packhouse still had a high frequency. This delineates between the situation where a high centrality score can come about through a factor being connected to many other factors with a low score or through a few factors with a high score.

The group map shows in detail that the orchardist as decision maker was influenced by weather and climate, regulations, customer requirements via ZESPRI, advisors, information, family needs, contractors/packhouse, orchard gate returns and cash orchard surplus. As decision makers, they were also influenced by some immediate factors of production such as fertiliser and soil fertility, weed and pest management, and quality and quantity of production. Decisions then influenced all the factors of production, including contractors/packhouse, but from these only fertiliser and soil fertility and weed and pest management have a link of four or more to quality and quantity of production. The other influences on quality and quantity of production were the decision maker, weather and climate, and soil type and topography. From production comes orchard gate returns although this is influenced by two other factors beyond direct control of the orchardist, ZESPRI and post-harvest quality, the latter influenced by the contractors/packhouse. Cash orchard surplus was driven from the combination of orchard gate returns and production expenditure, the latter, in turn, influenced by four factors of production: fertiliser and soil fertility, weed and pest control, labour and contractors and packhouse. Satisfaction was derived from cash orchard surplus and from quality and quantity of production.

Other important features of the group map were:

- Fertiliser and soil fertility, and weed and pest management, were the only factors of production with a strong link to quality and quantity of production, not labour or machinery.
- There were four main circuits: a production circuit, a production-related circuit (including post-harvest quality), an expenditure circuit, and a fruit sales circuit.
- Fertiliser and soil fertility, weed and pest management and contractors/packhouse were the only factors of production with feedbacks to decision maker.
- Some factors, such as weather/climate, regulations and soil type/topography influence the system but over which the orchardist has little control.
- Orchard environment health was mainly influenced by the decision maker.
- All bidirectional arrows included the decision maker

In summary, the group map highlights the overall similarities derived from all orchardists across the panels. While all 36 factors on the generic map received some attention from some growers at some point in the research process, the vast majority of causal connections within the basic kiwifruit system related to the select minority of factors shown in Figure 6 above. Further, there were not many bi-directional arrows. While some orchardists linked factors in both directions, this was infrequent and the scores were low (for example, quality and quantity was linked to fertilisers and soil fertility at 0.2). Even the feedbacks to the decision maker were limited.

Exploring the system properties of the map showed that in its final equilibrium state, satisfaction has a high level while marketing organisation (ZESPRI) and contractors and packhouse have a lower level. Results from zeroing outgoing connections confirm the importance of the decision maker. Results from maximising outgoing connections, which had a stronger effect compared with zeroing, showed that maximising satisfaction created the most change. Overall, the causal map system is stable. Significant change would occur only if a number of factors were changed, including the decision maker.

While the total group map data was interesting, the ARGOS project is particularly interested in the similarities and differences between the Gold, Green and Organic panels of growers. The most obvious way to evaluate differences between the Gold, Green and Organic panels was through means data. The main differences were:

- Causal influences on production expenditure were more important to Gold and Organic compared to Green. This was because:
 - Gold had a high score for labour.
 - Organic had a high score for fertiliser and soil fertility.
- For Gold, information was more important to the decision maker.
- The causal influences of weather/climate, contractors/packhouse and labour on quantity and quality of production were more important to Green compared to Organic.
- The causal influence of the decision maker on orchard environment health were more important to Organic compared to Gold.
- The causal influence of orchard environment health and orchard as a place to live on satisfaction were more important to Organic.

Frequency data showed differences between the panels:

- Similar to the above, contractors/packhouse had more connections for Green compared to Organic.
- The decision maker had more connections for Organic compared to Green, and production expenditure had more connections for Organic compared to Green.
- Orchard environment health, regulations, government policy, off-farm activities and community had more connections for Organic compared to Green.

Indegree and outdegree analysis showed differences between the panels:

- Indegree means of cash orchard surplus and improve equity were higher for Gold.
- Location was more influenced by other factors for Gold compared to Green.
- Customer requirements had less influence on other factors for Green compared to Gold and Organic.
- Grower groups/organisations was connected to more factors for Gold compared to Green or Organic.
- The causal influence of the decision maker on fertiliser and soil fertility, plant and machinery, and time in farm work were more important for Organic.

These results allowed the group map (Figure 2) to be amended to show the main differences between the panels, as follows, and illustrated in Figures 26 and 27:

- Organic:
 - The decision maker was linked to orchard environmental health at a slightly higher level (6 compared to 5).
 - Orchard environment health was linked to satisfaction at a higher level (5 compared to 3).
 - Orchard environment as place to live was linked to satisfaction at a higher level (5 compared to 3).
 - Fertiliser and soil fertility was linked to production expenditure at a slightly higher level (6 compared to 5)
 - Regulation was linked to the decision maker at a slightly higher level (7 compared to 6).
 - Orchard gate returns was linked to decision maker at a slightly higher level (5 compared to 4).
 - The decision maker was linked to fertiliser and soil fertility at a higher level (8 compared to 6)
 - The decision maker was linked to plant and machinery at a slightly higher level (6 compared to 5)
 - The decision maker was linked to time in farm work at a higher level (8 compared to 6).

Figure 26: Key distinguishing features of the Organic group map

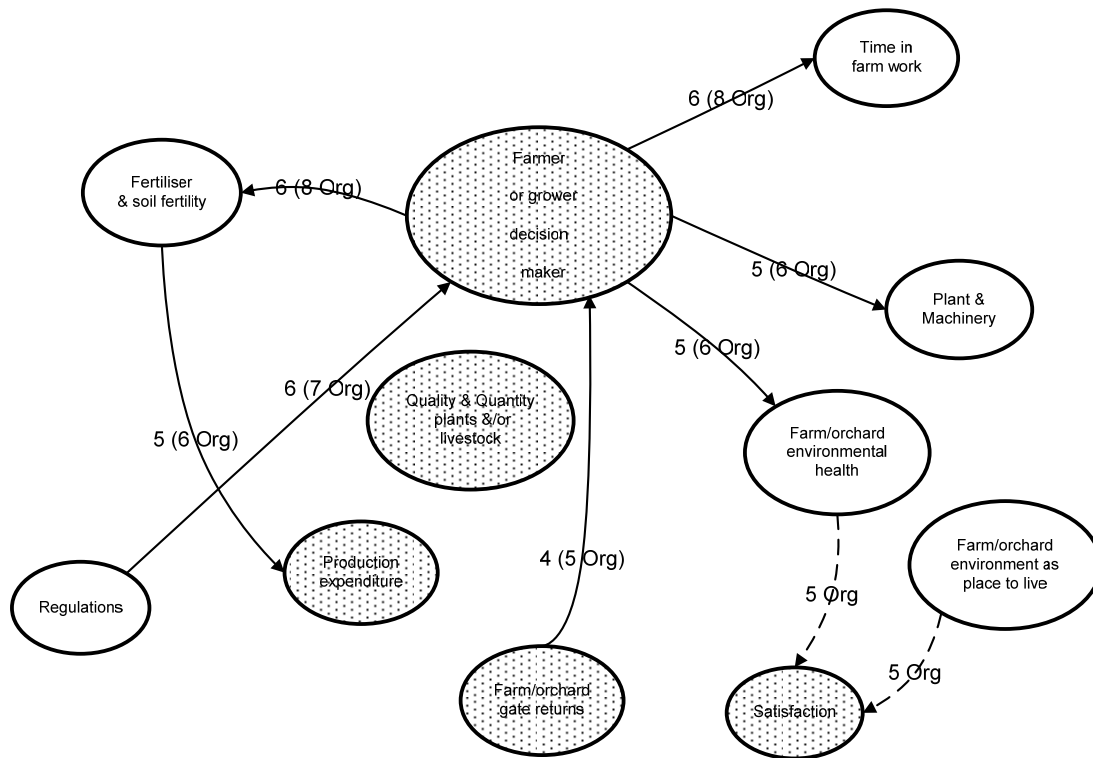
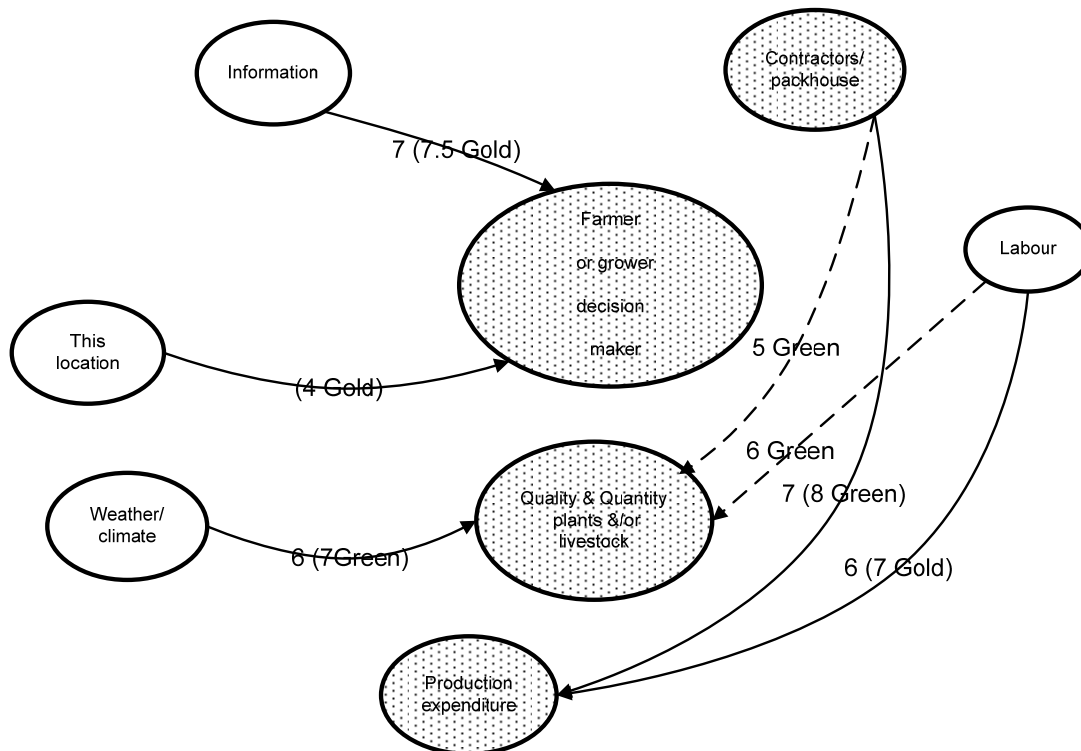


Figure 27: Key distinguishing features of the Green and Gold group map



- Green:
 - Contractors and packhouse was linked to quality and quantity of production at a much higher level (5 compared to 2).
 - Labour was linked to quality and quantity of production at a much higher level (6 compared to 3).
 - Contractors and packhouse was linked to production expenditure at a slightly higher level (8 compared to 7).
 - Weather/climate was linked to quality and quantity of production at a slightly higher level (7 compared to 6).
- For Gold:
 - Labour was linked to production expenditure at a slightly higher level (7 compared to 6).
 - Information was linked to decision maker at a fractionally higher level (7.5 compared to 7).
 - Location was linked to the decision maker at a higher level (4.4 compared to 2.6).

While most attention has been given to causal connections that were higher for a particular management system some were notable for being very low.

- Weed and pest management effect on production expenditure was very low for Green.
- Plant and machinery effect on production expenditure was very low for Gold.
- Soil type and topography, and labour, on quality and quantity of production were very low for Organic.
- Quality and quantity of production on satisfaction was very low for Organic.

Location explained some of the variance in the centrality data in ways that were expected. For both contractors/packhouse and cash orchard surplus, location was relevant for both means and frequencies.

Returning to the issue of complexity of perceived farm management systems, there were differences in the sheer number of causal connections between Organic and Green and Gold. Gold and Organic had more causal connections, and similarly, Gold and Organic had more double arrows than Green.

4.4 Discussion and Interpretation

The data allow us to directly address not only substantial questions about the way growers perceive their orcharding system (allowing us to analyse their maps either for the whole group or in terms of basic similarities and differences between panels), but also some wider debates in sustainable agriculture (holism of management, perceived complexity of farming systems). However, first we will discuss the main results.

A group map was able to be produced which mainly showed the common causal connections among the key factors. While there were some significantly different causal connections for each panel these were still outnumbered by the common causal connections indicating that there is much that was similar across the panels.

As it happened there did not seem to be causal links that were completely cancelled out by contradictory causal connections. It was more a case of variation around an average. Accordingly, this range of scores lowered the score averages so that a modest score of 4-5

still indicated a reasonably important connection according to the criteria we developed to interpret the group map. Further, the 36 factors provide opportunity for a wide variety of connections to be made and this meant that many of the connections important at the individual level did not show up for the group map

Meta analysis worked well. While each orchard is unique, there was sufficient similarity in the relevance of the factors and how they were connected that obvious patterns emerged and the resulting group map represented kiwifruit orcharding generally. If there were wide differences between orchards then we would not have found a coherent pattern.

The key points emerging from the group map were:

1. The group map shows an overall productive orientation of orchardists. The centrality data show that the most important factors were decision maker, quality and quantity of production, ZESPRI, financial factors and satisfaction, mainly derived from the former factors. This held across all panels indicating that the growers were not particularly eco-centric, but took a very production focused (human-centric) approach to their orcharding system. This is entirely consistent with other research in New Zealand which shows that farmers consider sustainability first in financial terms (e.g., Blunden and Cocklin, 1995; Andrew et al., 1997). Only a minority of orchardists provided causal maps that gave prominence to environmental factors as involved in the orchard system. There were two in the Organic panel and two in the Green panel who gave emphasis to orchard environment health, and there were three in the Green panel, two in the Organic panel and two in the Gold panel who gave emphasis to orchard environment as a place to live.

2. Labour and plant and machinery, as two of five factors of production, were not an important part of the group map. Labour is needed to manage kiwifruit vines and to harvest kiwifruit so it is likely that it potentially has an important effect on quality and quantity of production. The low level of importance attributed to these two factors may have been because they are often supplied by the contractor/packhouse. But even so they are still a factor in the system. In any discussion with orchardists about labour it will be apparent that labour appears to be an important issue but this is more related to supply and ongoing difficulties with labour rather than the role of labour in the system. It may also be due to the fact that much orchard work is done by contractors or the pack house and/or the decision maker and therefore labour represents less important orchard activities. Another possibility is that at the time of interview, March and September, harvesting was not a priority and the labour issues may have been less important. The other three factors of production, fertiliser and soil fertility, weed and pest management and contractors/packhouse, were more important in their links to quality and quantity of production and through having feedbacks to decision maker. It remains possible that orchardists are underemphasising an important factor in their system. Plant and machinery may not show as prominent factors because they are not problematic and do not play a contentious or significant role in orchard management. That is, plant and machinery are essential but they are not a big issue. In many cases the contractors use their own machinery and many orchardists do not have much machinery.

3. Orchardists emphasised the role of some factors which have an important influence on the system but over which they have little control, for example, weather and climate, soil type and topography, ZESPRI, and information and advisors. As mentioned in the results, orchardists are not powerless in the face of these factors and they take management actions in response to them. These influential factors add to the complexity of the system that orchardists manage.

The key points emerging from differences between the panels include:

1. The effect of labour on production expenditure was more important to Gold. Examination of actual production expenditure shows that Gold was significantly higher than Organic at the

five per cent level, and significantly higher than Green at the ten per cent level. Presumably the high yields and vigorous growth typical of Gold means that labour is more of an issue. It is not the case that the Gold orchards are larger than average: the sizes are as follows: Gold 2.96, Green 3.64 and Organic 3.81 and there is no statistically significant difference between them. Further, information was more important to the decision maker, perhaps because Gold is a new crop and less is known about how to grow it so these orchardists had greater need for information or valued it more highly. Accordingly, Gold gave more importance to grower groups and organisations.

2. The causal influences of weather/climate, contractors/packhouse and labour on quantity and quality of production were more important to Green compared to Organic. Contractors/packhouse had more connections for Green. Green appears to emphasise factors beyond their immediate control among those that influence production. Contractors and packhouse was linked to production expenditure at a higher level. Perhaps many Green orchardists use contractors/packhouse to do much of the work and therefore the costs are relatively high. These results suggest that Green orchardists have less direct influence on their system than Gold or Organic, or that they believe that they are more at the mercy of other people. Perhaps also they had greater faith in the capacity of others to assess and respond to the influences present in the system. We have observed that more Green orchardists are closer to retirement and may be seeking less responsibility for day to day orchard management.

3. The decision maker was linked to the factor of fertiliser and soil fertility at a higher level for Organic compared to Green or Gold. Organic orchardists see this factor as very important in their system and pay particular attention to the soil. Perhaps they use either more inputs or more expensive inputs so their connection of soil and soil fertility to production expenditure is at a higher level. Their awareness of these amounts and costs may explain why orchard gate returns are linked to decision maker at a higher level. Table 15 below shows the average amount of fertiliser applied to Gold, Green and Organic orchards in kilograms per hectare in 2003/04. Organic orchardists apply most fertiliser largely driven by the amount of compost. However, analysis of financial data for value of fertiliser applied does not show any difference between the three panels. This suggests that the higher weighting given by Organic orchardists to fertiliser and soil fertility may reflect their belief in its importance. Some of the organic fertiliser techniques require considerable inputs to make compost or compost teas for example. This would take time rather than money.

Table 15: Amount of fertiliser (Kg/ha) applied by each panel

	Gold	Green	Organic
NPKSMg	530	440	150
Lime	330	250	50
Compost	250	350	4,430
Total	1,110	1,540	4,630

Emphasis was given by Organic orchardists to regulation and its influence on decision maker which is a consequence of being certified. Another theme for Organic was the importance of the environment. They pay less attention to quality and quantity of production and more to orchard environmental health. The effect of the decision maker on orchard environment health was more important to Organic compared to Gold and the causal influence of orchard environment health and orchard as a place to live on satisfaction were more important to Organic. Clearly, the state of their environment is an important part of the organic orchard system. In addition, for some factors, Organic had more connections. Decision maker had more connections compared to Green, and production expenditure had more connections compared to both Green and Gold. Also, orchard environment health, regulations,

government policy, off-farm activities and community had more connections for Organic compared to Green. Overall then, Organic orchardists see their system is having more connections, among which was the decision maker, and this fits observations from the interviews that decision making was very important to Organic orchardists and that they were more conscious of its role in their system.

4. In terms of the panel differences, in some cases the Organic means were similar to the Gold means. They both had more double arrows compared to Green. Both gave more attention to customer requirements. This suggests that on some dimensions, Gold and Organic were similar. Perhaps they are both alternative systems, each drawing the orchardists into new ways of doing things that are consciously different from Green. Greater attention is given to the factors and their connections.

The group map includes orchard environment health but this factor was not strongly integrated into the system. The main link to orchard environment health was from decision maker, and only for the Organic panel is there an additional link from it to satisfaction. It seems plausible to believe that in any productive ecosystem at least the management activities relating to fertiliser and soil fertility and weed and pest management would have some effect on orchard environmental health but these connections were not seen as strong and they were given an average score of one. Figure 5 presented earlier shows a connection between orchard environment health and quality and quantity of production with a score of two, indicating that those who did connect orchard environment health made the connection from it to other factors rather than the other way around. There is also potential in a kiwifruit orchard for contractors/packhouse, labour, and plant and machinery to have an effect on orchard environmental health. These were scored at one, zero and zero respectively. These data show that even if orchardists believed that orchard environment health was important and was at a good level, in the aggregate they do not see that its status was linked to anything other than the decision maker. This finding suggests that orchard environment health is not in fact rated as very important in the orchard management system.

This finding may be due to the widespread use and acceptance of the Kiwigreen system which, from an orchardist's point of view, may mean that the environment is taken care of because the management system to protect the environment is in place.

On average, the score for the link from orchard environmental health to satisfaction was low at three but it was moderate for Organic at five. If orchard environment health becomes an important issue in future then the results for the Organic orchardists suggest that one way to emphasise this factor is to somehow link it to satisfaction. We know that satisfaction is driven by quality and quantity of production and by cash orchard surplus so linking orchard environment health to these production related factors is another potential way of making it more relevant to the orchardist.

Assuming that change in the system may be needed for whatever reason, we note that while the centrality data point to important factors, this importance is relative. There may well be key factors with low average centrality but which may play an important part in change. This observation is very relevant at the level of the individual map where some factor or factors other than those identified as important in the group map can play a key role. Beyond this qualifier we can note that overall, the kiwifruit system as represented by the group map is stable. Significant change would occur only if a number of factors were changed, including the decision maker.

The group map results also raise a very important question about the complexity of orcharding systems as perceived by growers. Is orcharding a complex system? Galmiche-Tejeda (2004) argue that farmers think holistically and in terms of complex systems of relationships and therefore recommend that research methods be used in ways that are appropriate to this reality. Our results suggest at first glance that kiwifruit orchardists tend not

to think in terms of very complex systems, but reduce their orchard management down to eight key relationships, most of which are related to production and financial considerations. This is true at the level of the group map: it shows indeed that the eight key factors with the main influence on the system are production related. At the group level we suggest that our results are pointing towards an answer to our question which is that orcharding is not a complex system.

But does this mean that each orchardist has a simple view of the orchard system? We suggest not because each individual map has important additional factors and connections which lie outside the basic map and yet for that orchardist are very important. These additional connections make their map complex. Remember that on average, 31 out of the 36 factors were connected at some level, showing that each individual map had many connections. In addition, as the data on the linkages less than four illustrate, there are some connections that are very important but have not been systematically selected and scored by each orchardists with a high enough score or frequency to have an average score of four or more. To illustrate this point we introduce some additional data from the maps. Data on the centrality of each factor for each orchardist (see Appendix 3) were examined paying attention to those factors other than the top eight. In all but five cases there were centrality scores at least two times the average centrality score. One map had ten above average centrality scores, one had six and some had four such factors. On average there were at least two factors with above average centrality scores. This means that these factors with high centrality scores figured prominently in their individual maps. Further, the influence was high and larger than the top eight factors.

Further, on this question of orchard complexity, the results show that Organic orchards had higher frequencies of connections between some factors and this indicates that they view their orchards as more complex than Green or Gold orchardists.

However, given the overwhelming effect of the top eight factors in the group map there is a sense that the kiwifruit group map is relatively simple in that it contains all the key financial factors plus satisfaction. This is true for the group as a whole. So if you ask the question about the complexity of an orchard system then at the level of the group the system is not overly complex, but if you ask the question at the level of the individual orchard the system is complex. This was reflected in the observation that the mapping process was demanding for the orchardists to complete because it involved consideration of many factors. When the orchardists were asked about the mapping process the common response was that "It makes you think!". Thus, even though orchardists are responsible for many of the factors in their system it is not easy to manage the system. It may be the case that the difficulty in preparing the map to represent their systems reflects the difficulty in managing their systems, and may reflect that causal mapping is not well suited to representing their conception of their system.

In many ways our analysis of the data from the mapping also reflects orchard complexity. We had chosen to focus initially on the average map with scores of four or more in order to reduce the complexity so that the group map was intelligible. What this is showing is that systems are hard to grapple with both for orchardists and researchers. This is an important finding in itself because it reminds of the complex nature of farm and orchard systems.

While we are arguing for a qualified answer to the question: Is orcharding a complex system?, there is a related question to answer: do orchardists think holistically? If they think holistically then they would be unlikely to make predominant use of one type of factor when preparing their maps. Our results show that for the group map there is no question that orchardists use mainly production and financial factors as the core part of their map. Even the individual maps are still largely driven by production or financial factors, albeit with some other types of factors used in important ways in their maps. The basic centrality data presented early on in the results chapter shows as an inescapable fact that most of the

factors that have predominantly social characteristics, such as family needs, neighbours, community and family history and background have very low centrality scores. Most of the factors that have a predominantly environmental characteristic have modest scores, for example, orchard environment health and orchard as a place to live. Because these mainly social or environmental factors have low centrality we have to conclude that, overall, orchardists do not think holistically.

The results show that in terms of sites of action, that is places where action to achieve sustainability may occur, since the focus of most orchardists is on production, any future issues of change relating to sustainability would need to be linked to production factors in order for them to register as important. Accordingly, if environmental issues were to become important, they would have to be linked to production and financial factors. Or it could mean that any environmental concerns or practices have to be addressed in terms of their impact on production. In a sense then, the emphasis on production factors is acting as a constraint on environmental considerations. Few orchardists made any connection from a factor of production to orchard environment health while a few made links from orchard environmental health to production.

4.5 Limitations and future research

The causal mapping method is a hybrid method but it does not do full justice to its qualitative dimension. We do not know in full what the orchardists took the meaning of each factor to be. This could be addressed by recording the discussion about some or all the factors used by the orchardist. Analysis of the discussion would show how the orchardist gave meaning to the factor.

An issue raised in Chapter 2 was whether the generic map influenced how the orchardist responded to the mapping process. It is highly likely that the placement of the factors on the generic map influenced responses and this must be the subject of further methodological refinement. Perhaps the factors furthest away from decision maker were less likely to be used because they were on the perimeter of the generic map. There is no easy way around this in the context of a generic map, because any structure provided with the generic map must have some influence on the participant. One alternative would be not to use a map but to use the matrix spreadsheet and ask participants to consider each factor's effect on each other factor and assign a score⁶. However, this approach still has questions of framing since the factors have to be ordered in some way and there will be a tendency for factors listed at the extremes to be overlooked. It also is moving away from mapping of a system. The question of the influence of the generic map on the mapping procedure raises the question whether the method obscured the recording of orchardists' view of the system. Perhaps our results just discussed above, showing in some respects that the kiwifruit orchardists may not be holistic thinkers, was due to the method? The following suggestions of an alternative method for mapping would address this question.

A better approach would be to use the factors in a more interactive way. This could be done by putting each factor on a card and asking each farmer, as first step, to indicate the importance of each factor. This indication could be obtained by asking the farmers to sort them into groups of high, medium or low/no importance. This phase would allow farmers to become familiar with each factor and it would allow later analysis of these initial data, for example by Q sort methodology which is oriented toward finding groups of subjects who sort items in similar ways. Pre-testing would show whether this process would make sense to farmers given that they would have no obvious reference to which to make an assessment of importance. Following this first step each farmer would then take the factors already identified as important and put them onto a piece of paper to show how they are related.

⁶ This was suggested by Henrik Moller, ARGOS environmental objective leader, CSAFE, University of Otago.

They could move them around to best reflect their situation. Then they would draw on the paper the arrows showing the connections, along with the strength of connection. Other factors could be added to achieve what the farmer believed was a full account of the important factors in their system. It may be useful to have blank cards available to allow for additional factors to be included. When the map was completed it could be recorded manually, perhaps by gluing the cards to the paper, or by taking a photograph as a back up⁷. During this mapping process farmers would be free to move factors around to best express their views although there might be some limitation if lines are already drawn and they need to be amended.

The mapping exercise raises the question of the appropriate scale at which to do the mapping. It is possible that narrowing the focus to parts of the system may make it a more readily understood task that is both easier to do and easier to interpret. However, this would mean that we would lack understanding of farmers' view of the whole system. Our results are different from Ozesmi and Ozesmi (2004) but this is because they were studying stakeholders' views of one ecosystem such as a lake, so this focus takes the farmer beyond their farm. In future, there may be merit in going broader to match such a landscape focus. This might encourage stronger emphasis on non-farm factors such as other farmers, neighbours etc. However, the focus on the farm as a whole seems the best place to start. Another possibility would be to do separate maps for each of the social, economic and environmental areas assuming that this would be relatively easier to do. However, it is not clear how to integrate each separate map into a combined map.

Another methodological innovation would be to allow different household members to create maps. This would enable gender, age and other demographic differences to emerge. Of course other stakeholders in the system under consideration could also be included such as industry representative or scientists.

Another limitation is that we have drawn attention to panel differences in the causal connections between some factors. While this is interesting, particularly where they cohere in developing an understanding of the characteristics of a panel, in some cases the difference of score was only one on the ten point scale. Such a score difference may not be all that meaningful.

Relating to the analysis of panel differences is the question of whether the panel is the best way of partitioning orchardists. There may be other ways of grouping orchardists. We ran some cluster analysis on the data but found no obvious other groupings. However, this is one area where more work could be done by trying different clustering techniques.

Future research could explore the idea that orchardists could be rated on the complexity of their systems as represented by the causal maps. Relevant criteria would be to use the number of connections and the sum of the centrality scores and assign those with high scores to the high complexity group. These groups could then be assessed on environmental or ecological variables to see if there is any relationship. Results here would have important implications for communicating sustainability policy.

⁷ Professor Simon Swaffield, Lincoln University, suggested these alternative ways of obtaining a map.

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Appendix 1: Kiwifruit group map data

	Community	SH/subdivision	Family history	Weather/climate	This location	Soil type/topography	Regulation	Customer requirements	Marketing org	Exchange rate	Government policies	Neighbours	Family needs	Information	Advisors, consultants	Fert and soil fert	Weed and pest mgmt	Decision making	Quality and quantity of production	Production expenditure	OGR	CO Surplus	Contractors & packhouse	Labour	Plant & machinery	Farm/orchard env health	Post harvest quality	Improve equity/land size	Time in farm work	Grower groups or orgs	Off farm activities	Off-farm work	Farm/orchard place to work	Satisfaction	Retirement	Future generations	
Community	0.0	0.6	0.0	0.0	0.3	0.0	0.4	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	2.67	
SH/subdivision	0.5	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.0	2.36	
Family history and b/g	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	2.03		
Weather/climate	0.0	0.2	0.0	0.0	1.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.6	5.4	5.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.8	0.3	0.0	15		
This location	0.1	0.2	0.0	1.2	0.0	0.8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	1.1	0.6	0.0	9.56		
Soil type/topography	0.0	0.0	0.0	0.2	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.6	0.0	3.4	3.7	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	9.92			
Regulation	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.3	3.3	0.0	0.1	0.0	0.0	0.0	0.4	0.0	0.5	5.9	0.1	0.3	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.5		
Customer requirements	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	7.4	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11		
Marketing org (Zespri)	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.7	0.0	0.0	0.4	0.0	0.0	0.7	0.4	0.0	0.0	6.8	0.1	0.0	5.2	0.2	2.4	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5		
Exchange rate, macro	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.3	3.1	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.58		
Government policies	0.0	0.1	0.0	0.0	0.0	0.0	2.0	0.0	3.3	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.36		
Neighbours	0.1	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.6	0.0	4.22			
Family needs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.3	0.0	0.4	0.0	5.78			
Information	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.4	0.0	0.0	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	7.53			
Advisors, consultants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.4	0.0	0.7	0.4	5.6	0.2	0.8	0.0	0.1	1.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.81		
Fert and soil fert	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	3.8	5.2	5.3	0.0	0.0	0.2	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.6		
Weed and pest mgmt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	4.3	3.9	0.0	0.2	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	13.6			
Decision making	0.1	0.2	0.2	0.3	0.6	0.4	0.0	0.2	0.5	0.0	0.2	2.1	3.3	0.5	1.1	6.5	6.0	0.0	7.0	1.2	1.0	0.2	4.8	5.1	4.7	5.4	1.5	1.9	6.1	1.0	3.2	2.1	2.1	1.5	1.1	73.4	
Quality and quantity of production	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	5.2	0.0	0.4	7.5	0.7	0.0	0.0	0.3	3.7	0.1	0.5	0.0	0.0	0.0	4.3	0.0	0.0	22.8		
Production expenditure	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.4	0.0	1.4	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.25		
OGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	3.9	0.0	0.3	0.0	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.2	0.1	15.6		
CO Surplus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0	0.2	0.2	0.1	4.5	0.7	0.4	13.8	
Contractors & packhouse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.1	0.2	0.3	1.0	0.9	5.3	2.2	6.8	1.9	0.0	0.0	1.6	0.5	0.6	4.8	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	27.1		
Labour	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	3.3	5.8	0.0	0.4	0.0	0.4	0.0	0.4	0.0	1.4	0.0	0.0	0.0	0.2	0.0	0.0	13.9		
Plant & machinery	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5	1.6	1.7	2.7	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.2	0.0	0.0	0.3	0.0	0.3	0.0	0.0	7.94		
Farm/orchard env health	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	1.9	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	2.4	3.1	0.0	0.4	10.8		
Post harvest quality	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.2	0.2	5.5	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	8.94		
Improve equity/land size	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	1.8	0.3	4.83		
Time in farm work	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	1.9	0.4	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.3	0.0	0.0	2.8	1.0	0.3	0.1	0.0	7.69		
Grower groups or orgs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.4	0.0	0.0	4.86		
Off farm activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.3	1.2	0.0	0.0	2.94		
Off-farm work	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.1	0.0	0.0	0.3	0.0	0.0	2.44		
Farm/orchard place to work	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.1	0.0	0.4	0.0	0.3	0.0	0.0	0.3	0.0	3.3	1.1	0.6	7.56		
Satisfaction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	2.25			
Retirement	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.44			
Future generations	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.36			
Column Total-Indegree	1.39	1.3	0.5	1.6	3.5	1.6	7.1	1.2	21	1.8	1.1	2.4	5.3	2.4	3.5	9.5	9.1	94	39	29	26	17	9.9	7.3	5.6	9.6	12	6.7	12	1.2	6.8	3.8	7.6	28	5.7	3.3	398
Row total-Outdegree	2.67	2.4	2	15	9.6	9.9	12	11	21	9.6	9.4	4.2	5.8	7.5	9.8	16	14	73	23	9.3	16	14	27	14	7.9	11	8.9	4.8	7.7	4.9	2.9	2.4	7.6	2.3	0.4	1.4	398
Centrality	4.06	3.6	2.5	17	13	12	19	12	41	11	10	6.7	11	10	13	25	23	168	61	38	42	31	37	21	14	20	20	12	19	6.1	9.8	6.3	15	30	6.1	4.7	22.1
Transmitter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11.6	
Receiver	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Ordinary	1	1	0	1	1	1	1</																														

Appendix 2: Panel indegree and outdegree analysis

Factor	Indegree means: Means of values given to connections between factors				Indegree frequencies: Means of number of connections to other factors			
	Gold	Green	Organic	Loc	Gold	Green	Organic	Loc
Decision maker	100.7	79.3	103.1		15.42	11.33	15.75	
Quality and quantity of production	36.1	48.0	30.8		4.83	6.25	4.33	
Orchard Gate Return	24.8	25.7	28.9		3.17	3.00	3.67	
Marketing organisation (ZESPRI)	19.1	19.4	23.7		2.58	2.50	3.25	
Production expenditure	32.5	22.7	30.8 ^{Note 2}	*	5.00	3.50	5.25	
	8.5	14.7	6.6		1.42	2.00	1.17	
Cash Orchard Surplus	20.0	16.3	15.7		2.33	1.92	1.92	
Satisfaction	27.3	27.8	28.3		3.58	3.42	4.00	
Fertiliser and soil fertility	9.3	9.8	9.3		1.25	1.25	1.25	
Weed and pest mgmt	8.3	10.8	8.3		1.25	1.42	1.17	
Labour	7.1	7.9	7.0		0.92	0.92	1.08	
Farm/orchard environmental health	7.4	9.4	11.9		1.25	1.25	1.67	
Post harvest quality	12.3	9.4	12.9		1.75	1.25	1.75	
Regulation	7.3	4.0	9.9		1.08	0.58	1.50	
Time in farm work	12.2	11.8	10.8		1.67	1.50	1.67	
Weather/climate	2.6	1.7	0.7		0.33	0.25	0.08	
Farm/orchard place to live	6.8	7.0	9.0		0.92	0.92	1.08	
Plant & machinery	4.6	5.8	6.3		0.67	0.83	0.83	
This location	5.0	1.3	4.3	**	0.58	0.17	0.67	**
Advisors, consultants	3.8	4.9	1.8		0.75	0.75	0.42	
Soil type/topography	2.3	0.6	1.8		0.33	0.08	0.25	
Customer requirements	1.8	1.5	0.2		0.25	0.17	0.08	
Improve equity/land size	8.3	6.8	2.6		1.00	0.92	0.50	
Exchange rate, macro economy	1.6	2.1	1.8		0.16	0.25	0.25	
Family needs	5.8	4.4	5.5		0.83	0.67	0.75	
Government policies	0.3	1.9	0.9		0.17	0.25	0.42	
Information	4.8	0.0 ^{Note 1}	2.6		0.67	0.00 ^{Note 1}	0.33	
Off-farm activities	6.0	8.0	6.4		0.83	1.00	0.92	
Neighbours	2.1	3.1	2.2		0.58	0.50	0.67	
Grower groups or orgs	1.0	1.2	1.5		0.33	0.25	0.33	
Off-farm work	2.9	4.7	3.9		0.42	0.58	0.58	
Retirement	7.9	5.1	4.1		1.17	0.67	0.58	
Future generations	3.3	3.9	2.8		0.58	0.50	0.33	
Community	0.9	0.5	2.8		0.17	0.08	0.75 ^{Note 3}	
Smallholding/subdivision	1.3	0.0 ^{Note 1}	2.6		0.17	0.00 ^{Note 1}	0.58	
Family history and b/ground	1.4	0.0 ^{Note 1}	0.0 ^{Note 1}		0.17	0.00 ^{Note 1}	0.00 ^{Note 1}	

Note: 1. No variation in panel – no links to other factors.

2. Gold and Organic significantly different from Green (5% level).

3. Gold and Green significantly different from Organic (5% level).

Factor	Outdegree means of values given to connections between factors				Outdegree frequencies: Means of number of connections to other factors			
	Gold	Green	Organic	Loc	Gold	Green	Organic	Loc
Decision making	67.4	69.5	83.3		9.83	9.42	12.83 ^{Note 3}	
Quality and quantity of production	23.7	22.9	21.8		2.92	2.67	2.75	
Orchard Gate Return	18.2	13.8	15.0		1.5	1.9	1.8	
Marketing organisation (ZESPRI)	21.5	20.8	19.2	*	2.92	2.58	2.58	**
Production expenditure	9.3	8.3	10.2		1.08	1.00	1.33	
Contractors & Packhouse	24.5	35.2	21.5 ^{Note 2}	*	3.50	4.50	3.25	**
Cash Orchard Surplus	10.5	15.9	12.6		1.50	1.92	1.83	
Satisfaction	2.8	0.5	3.5		0.42	0.08	0.42	
Fertiliser and soil fertility	14.9	13.7	18.2		2.25	1.92	2.42	
Weed and pest mgmt	13.2	12.2	15.3		2.42	1.92	2.42	
Labour	16.3	14.2	11.2		2.17	1.75	1.67	
Farm/orchard environmental health	8.7	8.0	15.8 ^{Note 3}		1.50	1.08	2.17	
Post harvest quality	7.8	8.2	10.8		1.00	1.00	1.42	
Regulation	11.1	12.0	11.5		1.75	1.58	1.58	
Time in farm work	9.2	8.8	5.0		1.33	1.17	0.92	
Weather/climate	14.4	15.7	14.9		1.83	1.92	2.00	
Farm/orchard place to live	8.9	5.0	8.8	**	1.25	0.58	1.17 ^{Note 6}	**
Plant & machinery	6.7	8.7	8.5		1.42	1.50	1.58	
This location	11.8	9.2	7.7		1.58	1.33	1.08	
Advisors, consultants	11.1	12.2 ^{Note 1}	16.1		1.83	1.18	1.17 ^{Note 5}	
Soil type/topography	9.8	10.4	9.6		1.33	1.50	1.33	
Customer requirements	12.5	9.0	11.4 ^{Note 2}		1.58	1.08	1.42	
Improve equity/land size	7.0	4.0	3.5		2.00	1.58	1.67	
Exchange rate, macro economy	10.2	10.1	8.5		1.25	1.25	1.08	
Family needs	7.7	3.3	6.3		0.92	0.58	0.92	
Government policies	7.7	7.2	13.2		1.08	1.08	1.92 ^{Note 3}	
Information	8.3	6.9	7.3		1.17	1.00	1.25	
Off-farm activities	3.5	1.6	3.8		0.50	0.17	0.67 ^{Note 6}	
Neighbours	5.3	4.8	2.6		1.08	0.67	0.83	
Grower groups or orgs	8.3	2.1	4.3		1.42	0.42	0.83	
Off-farm work	3.3	2.4	1.6		0.58	0.33	0.33	
Retirement	0.0 ^{Note 4}	1.3	0.0 ^{Note 4}		0.0 ^{Note 4}	0.17	0.0 ^{Note 4}	
Future generations	2.3	1.0	0.8		0.25	0.25	0.08	
Community	3.1	1.3	3.6		0.58	0.17	0.92	
Smallholding/subdivision	3.8	0.8	2.5	***	0.58	0.08	0.50	**
Family history and b/ground	2.7	1.3	2.1		0.42	0.33	0.50	

Note: 1. This result is rather distorted in all analyses by an outlier due to a particular orchardist who is very reliant on a consultant. If it is removed then Gold and Organic differ significantly (at 5% level).

2. Gold and Organic significantly different from Green (5% level).

3. Gold and Green significantly different from Organic (5% level).

Appendix 3: Centrality scores (means) by panel

Interview No.	Community	SH/subdivisio	Family history	Weather/clima	This location	Soil type/topo	Regulation	Customer req	Marketing org	Exchange rate	Government p	Neighbours	Family needs	Information	Advisors, con	Fert and soil	Weed and pest	Decision mak	Quality and	Production exp	OGR	CO Surplus	Contractors	Labour	Plant & mach	Farm/orchard	Post harvest qu	Improve equity	Time in farm work	Grower groups	On farm activities	Off-farm work	Farm/orchard place	Satisfaction	Retirement	Future generations
1	0	0	0	25	14	21	16	24	29	7	21	8	14	8	7	39	23	179	93	25	25	37	49	36	7	38	4	14	56	8	7	14	16	16	7	7
2	0	0	3	8	8	8	50	8	33	9	4	0	8	3	4	24	30	140	59	14	31	24	90	2	0	0	4	8	22	1	17	25	12	6	13	0
4	0	0	0	14	6	6	14	8	31	6	8	7	0	8	8	7	12	120	26	23	6	18	18	6	9	16	4	0	6	6	0	0	9	8	0	0
6	8	0	0	24	24	16	12	6	23	8	0	8	0	6	5	18	15	83	63	16	41	20	78	0	24	8	4	10	17	0	8	0	24	33	0	0
21	8	0	0	8	0	13	24	8	18	24	21	8	2	8	40	24	24	138	77	8	48	32	96	24	21	21	30	21	8	0	10	21	2	21	8	2
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